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U.S. ENVIRONMENTAL PROTECTION AGENCY

Office of Radiation Programs

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭ'lo
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'ko
10^{-15}	femto	f	fĕm'to
10^{-18}	atto	a	ăt'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb.
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

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RADIATION DATA AND REPORTS

Volume 13, Number 4, April 1972

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

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U.S. ENVIRONMENTAL PROTECTION AGENCY

William D. Ruckelshaus, Administrator

Reports

Distribution of Cesium-137 and Naturally Occurring Radionuclides in Sediments of Lake Michigan [1]

Philip A. Plato [2]

Measurements of radioactivity in bottom sediments of Lake Michigan were made during 1969 and 1970. The only manmade radionuclide found was cesium-137 which originated from over two decades of atmospheric testing of nuclear weapons. A correlation was observed between accumulation of cesium-137 in sediments and water current patterns in Lake Michigan. Concentrations of naturally occurring potassium-40 and radium-226 were found to correlate with the type of sediment present.

Ten nuclear power reactors are scheduled for operation on Lake Michigan by 1976. The plants are owned by six power companies which formed "The Lake Michigan Utility Study Group" in order to study problems common to all the nuclear plants.

The Radiological Health Section of the University of Michigan conducted a study for the Lake Michigan Utility Study Group during 1969 and 1970 designed to measure radioactivity present in Lake Michigan before the majority of the nuclear plants become operational.[3] Approximately 400 samples of lake water, bottom sediment, phytoplankton, zooplankton, and benthos were collected and analyzed for radioactivity (*1*). Accumulation patterns, described in this paper, were observed for cesium-137, potassium-40, and radium-226 in the bottom sediments of the lake. Little or no radioactivity was detected in samples of the other environmental media.

Collection and analysis of sediment

Samples of sediment were collected at the 50 sampling stations shown in figure 1, which also shows locations, generating capacities and scheduled dates of operation of the 10 nuclear plants.

Sediment samples were collected with a Ponar dredge. The dredge collects sediment over a surface area of about 1,000 cm^2 to a depth of about 5 cm. Three samples were collected at most stations during three cruises of the University of Michigan's research vessel *Mysis*. The cruises were made during August and October 1969, and April 1970.

The samples were shipped to the Radiological Health Section of the University of Michigan for radioactivity analyses. Each sample was oven-dried at 110°C for 24 hours and transferred to a plastic counting container. The con-

[1] This research was supported by the Lake Michigan Utility Study Group, an ad hoc group comprised of representatives from American Electric Power Service Corporation, Commonwealth Edison Company, Consumers Power Company, Northern Indiana Public Service Company, Wisconsin Electric Power Company, and Wisconsin Public Service Corporation.

[2] Dr. Plato is assistant professor of radiological health in the Department of Environmental and Industrial Health, School of Public Health, The University of Michigan, Ann Arbor, Michigan.

[3] The Big Rock Point Nuclear Power Plant was the only operational reactor on Lake Michigan when this project was conducted. The Big Rock Point Plant will represent only 1 percent of the nuclear power produced on Lake Michigan by 1976.

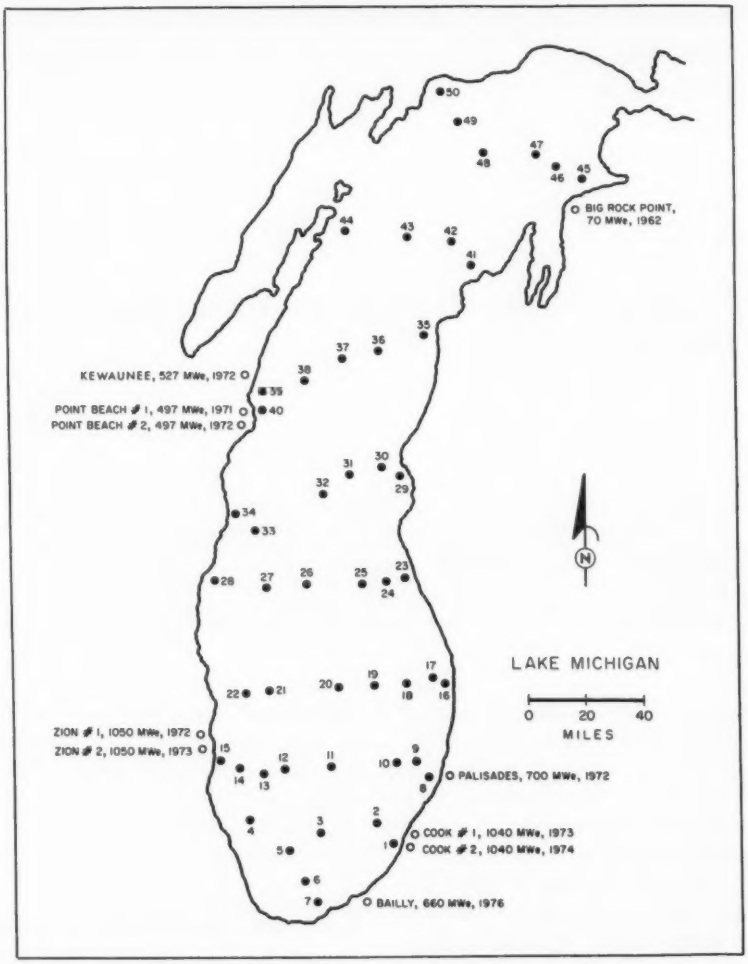

Figure 1. Sediment sampling stations in Lake Michigan (locations, generating capacities, and scheduled dates of operation of nuclear power plants)

tainers measure 10 × 10 × 6 cm and have snap-on tops.

A gamma-ray spectrum was obtained for each sample with a 12.5 × 10.0 cm (5 × 4 inch) NaI solid crystal and a 256-channel pulse height analyser. Spectra were stored on magnetic tape, and a spectrum analysis computer program (*2*) was used to make quantitative measurements of radionuclides present in each spectrum.

Cesium-137 was the only manmade radionuclide detected in any of the sediment samples. Naturally-occurring potassium-40 and radium-226 in equilibrium with its daughters were detected in the samples. Table 1 shows the concentrations of cesium-137 in each sample of sediment and average concentrations for each station.

It is reasonable to assume that all of the cesium-137 detected originated from fallout

Table 1. Cesium-137 concentrations in samples of bottom sediment taken from Lake Michigan

Station number	Cesium-137 concentration (pCi/g ±standard deviation)[a]			
	Sample 1	Sample 2	Sample 3[b]	Average
1	0.16 ±0.08	0.13 ±0.04		0.15 ±0.02
2	8.07 ± .32	.29 ± .07		4.18 ±3.89
3	4.14 ± .21	3.44 ± .17		3.79 ± .35
4	.56 ± .04	.62 ± .04	0.84 ±0.05	.67 ± .12
5	1.29 ± .08	.52 ± .05	1.12 ± .07	.97 ± .33
6	1.02 ± .06	.83 ± .04	2.60 ± .13	1.48 ± .79
7	.49 ± .04	.08 ± .03	.75 ± .05	.44 ± .27
8	.20 ± .06	.09 ± .02		.14 ± .05
9	1.53 ± .18	.31 ± .03		.92 ± .61
10	1.37 ± .21	2.20 ± .13		1.78 ± .41
11	2.87 ± .20	2.59 ± .26		2.73 ± .14
12	1.90 ± .13	2.62 ± .16	5.86 ± .23	3.46 ±1.72
13	4.18 ± .17	4.19 ± .17	2.22 ± .22	3.53 ± .93
14	1.91 ± .10	3.78 ± .15	.99 ± .06	2.23 ±1.16
15	.14 ± .08	.17 ± .05	.23 ± .07	.18 ± .04
16	.24 ± .03	.67 ± .05		.45 ± .22
17	6.18 ± .25	4.17 ± .21		5.17 ±1.01
18	.88 ± .11	.53 ± .09	1.67 ± .13	1.03 ± .48
19	3.12 ± .22	4.13 ± .17	4.29 ± .17	3.85 ± .52
20	1.73 ± .28	1.09 ± .11	1.31 ± .12	1.38 ± .26
21	2.63 ± .13	1.66 ± .08		2.15 ± .48
22	1.36 ± .07	.96 ± .07	1.05 ± .07	1.12 ± .17
23	.83 ± .06	1.26 ± .08	1.13 ± .14	1.07 ± .18
24	.93 ± .10	2.39 ± .14		1.66 ± .73
25	2.75 ± .16	5.41 ± .22	1.23 ± .11	3.13 ±1.73
26	1.16 ± .09	1.33 ± .08	.49 ± .03	.99 ± .36
27	2.75 ± .14	1.88 ± .11	3.20 ± .13	2.61 ± .55
28	.73 ± .05	1.30 ± .08	.79 ± .06	.94 ± .25
29	.12 ± .02	.14 ± .02	.23 ± .03	.16 ± .05
30	.83 ± .06	.76 ± .05	1.37 ± .12	.99 ± .27
31	3.10 ± .19	5.44 ± .33	3.91 ± .20	4.15 ± .97
32	1.40 ± .24	.87 ± .10	.61 ± .12	.96 ± .33
33	2.44 ± .12	.44 ± .07	2.12 ± .17	1.67 ± .88
34	.56 ± .05	.58 ± .05	1.01 ± .06	.72 ± .21
35	.50 ± .05	.60 ± .10	.77 ± .06	.62 ± .11
36	.17 ± .14	.49 ± .13	1.02 ± .12	.56 ± .35
37	.22 ± .10	1.57 ± .14	.25 ± .07	.68 ± .63
38	.18 ± .12	.57 ± .16		.37 ± .20
39	1.00 ± .06	.70 ± .05	.85 ± .05	.85 ± .12
40	.17 ± .03	.25 ± .03		.21 ± .04
41	.94 ± .08	.20 ± .07	1.00 ± .08	.71 ± .36
42	1.55 ± .08	.84 ± .08	.62 ± .04	1.00 ± .40
43	.13 ± .10	.14 ± .10		.13 ± .12
44	.99 ± .07	1.00 ± .07		.99 ± .08
45	1.50 ± .09	1.21 ± .06	3.06 ± .15	1.92 ± .81
46	.66 ± .07	1.02 ± .05	2.80 ± .17	1.49 ± .93
47	.43 ± .06	1.34 ± .07	.42 ± .04	.73 ± .43
48	.25 ± .09	1.05 ± .27	.10 ± .07	.47 ± .42
49	.15 ± .07	.19 ± .08		.17 ± .02
50	.42 ± .05	.09 ± .03		.25 ± .16

[a] Errors calculated for each sample represent counting errors at the one sigma level. Errors calculated for average concentrations are sample standard deviations.
[b] A third sample was not collected at every station.

from atmospheric tests of nuclear weapons. Gustafson and Miller (*3*) indicate approximately 15,000 curies of fallout cesium-137 entered the Lake Michigan watershed between 1950 and 1970. The Big Rock Point Nuclear Power Plant discharged less than 6 curies of cesium-137 (approximately 0.04 percent of the cesium-137 that originated from fallout) into Lake Michigan between 1962 and 1970.[4]

[4] R. Sinderman. Consumers Power Company, Jackson, Michigan. Personal communication, November, 1971.

Discussion

Figure 2 shows average concentrations of cesium-137 in sediment according to station location. Contour lines of equal concentration, also shown in figure 2, indicate distinct accumulation patterns of cesium-137 in the sediments of the southern half of the lake.

Figure 3 shows surface water current patterns observed in Lake Michigan (*4*) together with cesium-137 contour lines established in figure 2. The Waukegan-Chicago-Gary area, a

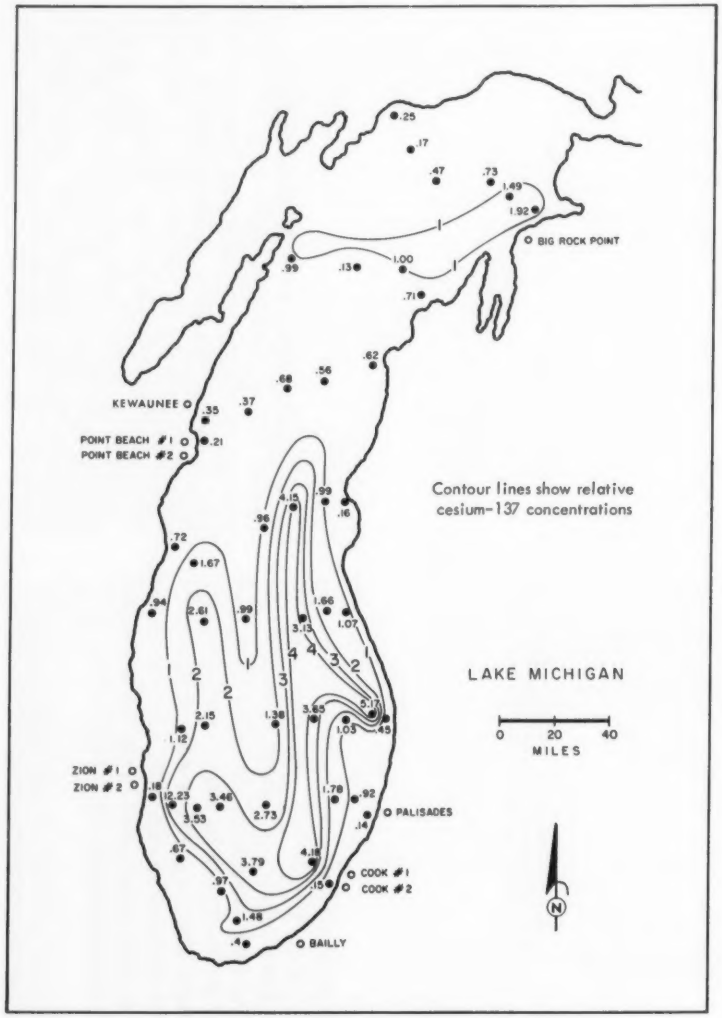

Figure 2. Average concentrations (pCi/g) of cesium-137 measured at each sediment sampling station in Lake Michigan (*1*)

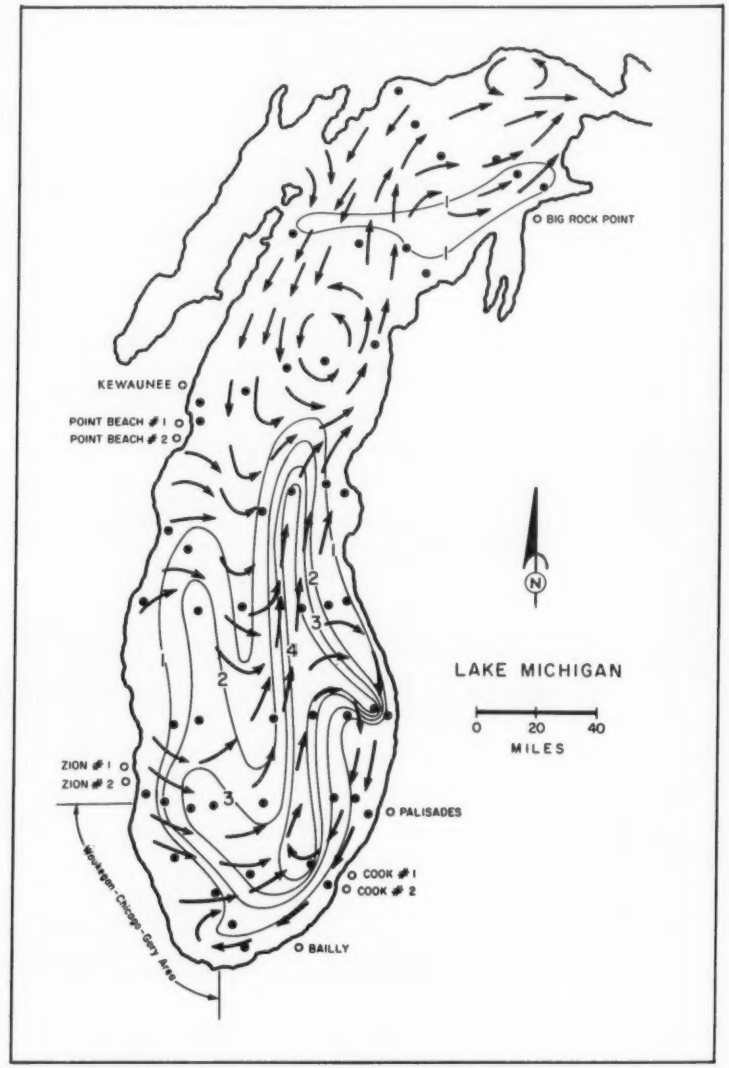

Figure 3. Surface water current patterns (arrows) (*4*) and cesium-137 accumulation patterns in pCi/g of sediment

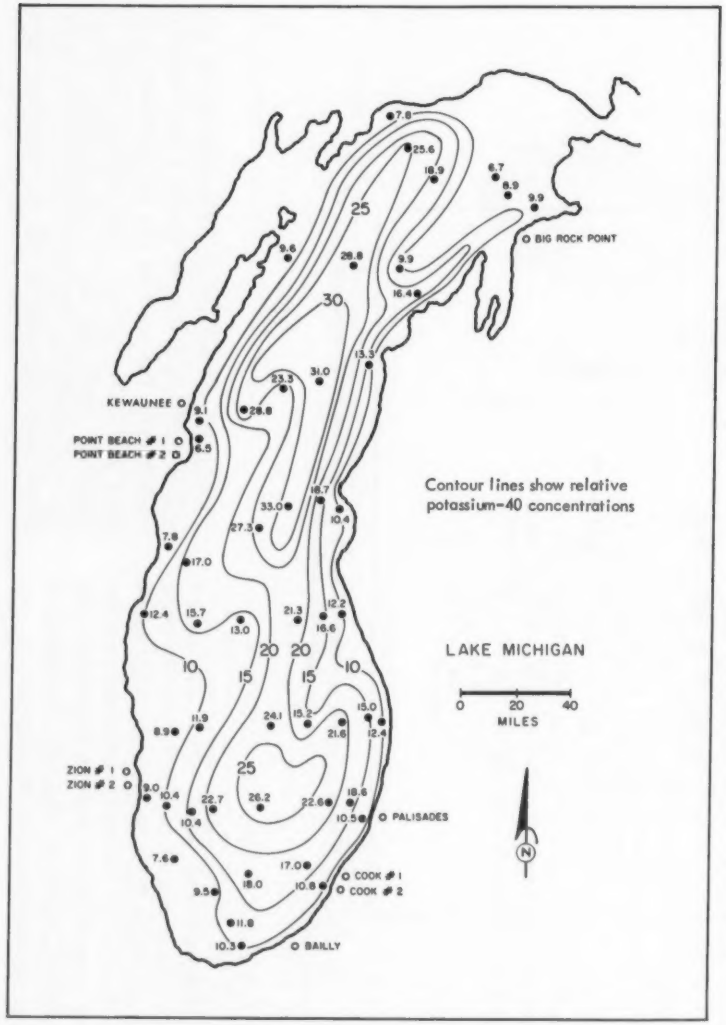

Figure 4. Average concentrations (pCi/g) of potassium-40 measured at each sediment sampling station in Lake Michigan

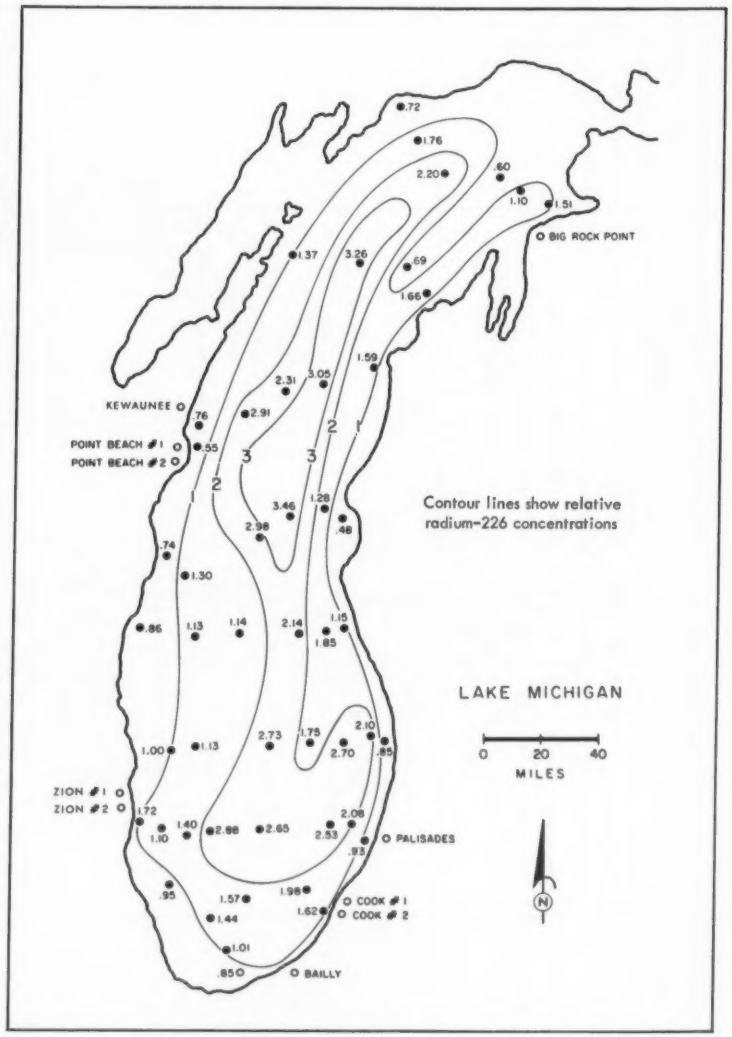

Figure 5. Average concentrations (pCi/g) of radium-226 measured at each sediment sampling station in Lake Michigan

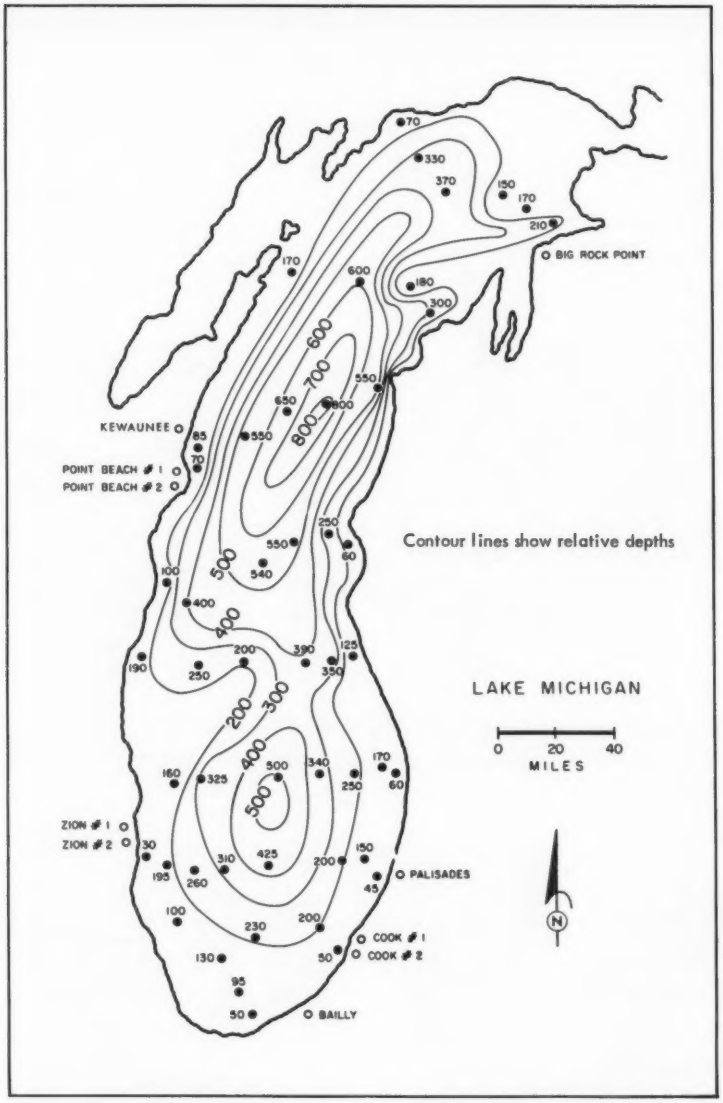

Figure 6. Average depth (feet) at each sediment sampling station in Lake Michigan

heavily industrialized area which discharges large amounts of suspended solids into the lake, is shown in figure 3. It is evident from figure 3 that a correlation exists between the concentration of cesium-137 in bottom sediments, the water current patterns, and the discharge of suspended solids into Lake Michigan.

Average concentrations of potassium-40 and radium-226 are shown in figure 4 and figure 5, respectively, for each of the 50 sediment sampling stations. Contour lines indicate areas of relatively high and low concentrations of the two radionuclides. Figure 6 shows the average water depth at each of the 50 sediment sam-

pling stations and contour lines representing relative depths of Lake Michigan.

Visual observations were made on each sample to determine the type of sediment present: clay, silt, sand, or gravel. Figure 7 shows that sediments around the periphery of the lake are predominantly sand; sediments in the middle of the lake are predominantly clay.

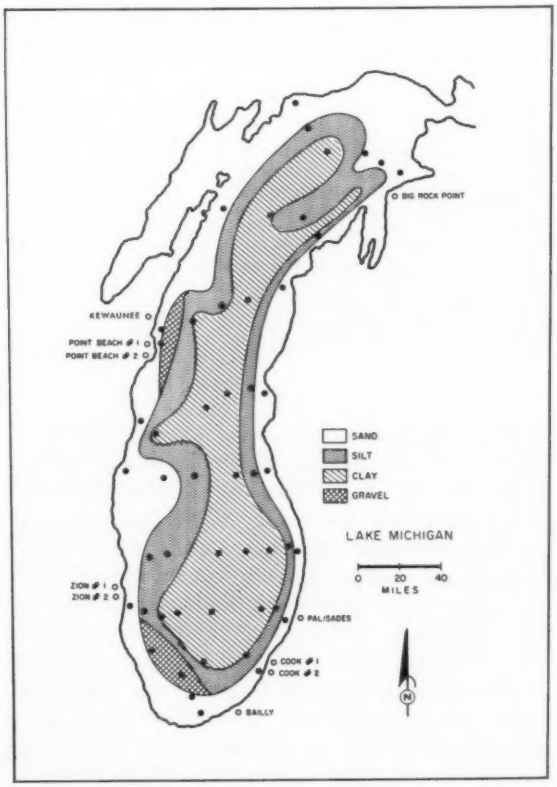

Figure 7. Types of bottom sediment found in Lake Michigan

Conclusion

Clay is the chemically active fraction of sediment and incorporates a variety of elements in its crystalline structure including silicon, aluminum, magnesium, calcium, potassium, and sodium (*5*). It is reasonable to assume that sediments having a high clay content will have a high content of potassium and radium, the latter being chemically similar to magnesium. A comparison of figures 4 and 5 with figure 7 shows this assumption to be valid.

Cesium-137 from fallout enters Lake Michigan uniformly in precipitation and runoff from the surrounding watershed. However, solids enter the lake nonuniformly; the heaviest loading comes from the Waukegan-Chicago-Gary area at the southern end of the lake. A likely explanation for the cesium-137 accumulation patterns in the bottom sediments is that much of the cesium-137 that enters the lake is adsorbed on particles that follow water current patterns and eventually settle to the bottom.

Fallout cesium-137 is a waste product that has entered Lake Michigan over a long period of time and at low levels. The present accumulation patterns of cesium-137 in the sediments of Lake Michigan may indicate future accumulation patterns of other waste products released into the lake under similar conditions.

Acknowledgements

The author wishes to acknowledge his gratitude to Dr. John C. Ayers, Professor of Oceanography, University of Michigan, for his guidance in the design and execution of this project, to Dr. John C. Golden, Commonwealth Edison Company, for his assistance in processing and correlating the data, while a graduate student at The University of Michigan, and to Dr. G. Hoyt Whipple, Professor of Radiological Health, University of Michigan, for his analytical review of the data obtained and conclusions reached.

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(*3*) GUSTAFSON, P. F. and MILLER, J. E. The significance of Cs-137 in man and his diet. Health Phys 16:167–184 (1969).

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(5) BAVER, L. D. Soil physics. John Wiley and Sons, New York, N.Y. (1965) p. 19.

Radioactivity Levels in Selected Ohio Streams; the Great Miami River, the Little Miami River, and Mill Creek; June-August 1968

Office of Water Programs
U.S. Environmental Protection Agency[1]

A water quality study of the Little Miami River, Great Miami River, and Mill Creek was conducted by the Office of Water Programs, U.S. Environmental Protection Agency. Analyses were performed for uranium, radium-226, lead-210, thorium and strontium-90. Uranium concentrations in the Little Miami River, Great Miami River, and Mill Creek averaged 0.4, 0.9, and 0.3 μg/liter, respectively. Radium-226 concentrations averaged 0.08, 0.11, and 0.04 pCi/liter, respectively. Strontium-90 concentrations averaged 0.7, 0.4, and 1.1 pCi/liter, respectively. The average thorium concentration was less than 3 μg/liter in all three streams. Lead-210 averaged less than 0.2 pCi/liter in the Little and Great Miami Rivers and 0.7 pCi/liter in Mill Creek.

As part of the comprehensive water quality study of the Little Miami River (*1*), Great Miami River (*2*), and Mill Creek (*3*), the levels of radioactivity in dissolved solids in these streams and their tributaries were determined. Radiological measurements include the quantitative identification of several natural radionuclides—uranium, radium-226, lead-210, and thorium—and the fission product, strontium-90. Although the selected list of naturally-occurring radionuclides is not all-inclusive, their combined concentrations provide a reasonable estimate of the background level. Strontium-90 was selected as the measure of residual radioactivity attributable to atmospheric fallout from weapons testing. Radiological water quality, often overlooked, is important to an overall evaluation of present and future potential utilization of a water source.

The sampling program was comprised of 2-week sampling periods with the following time schedule:

Survey area	Sampling period (1968)
Mill Creek	August 5-16
Little Miami River	June 24-28 and July 8-12
Great Miami River	
Stations 1-20	July 15-26
Stations 21-35, excluding Station 34	August 5-16
Stations 34 and 36-54	June 24-28 and July 8-12

For each station, radioactivity analyses were performed on a composite sample prepared from four daily surface grab samples (collected twice weekly). Each analysis was performed on a 1 liter aliquot of the composite sample. Figure 1 shows the study area and the general locations of the sampling stations.

Four nuclear installations are located within the bounds of the study area:

Feed Materials Production Center (FMPC) near Fernald
Mound Laboratory at Miamisburg
Wright Patterson Air Force Base at Fairborn
General Electric Company at Evendale.

[1] Engineering and Sciences Branch, Division of Applied Technology, Pollution Source Control Program, Office of Water Programs, U.S. Environmental Protection Agency, Cincinnati, Ohio.

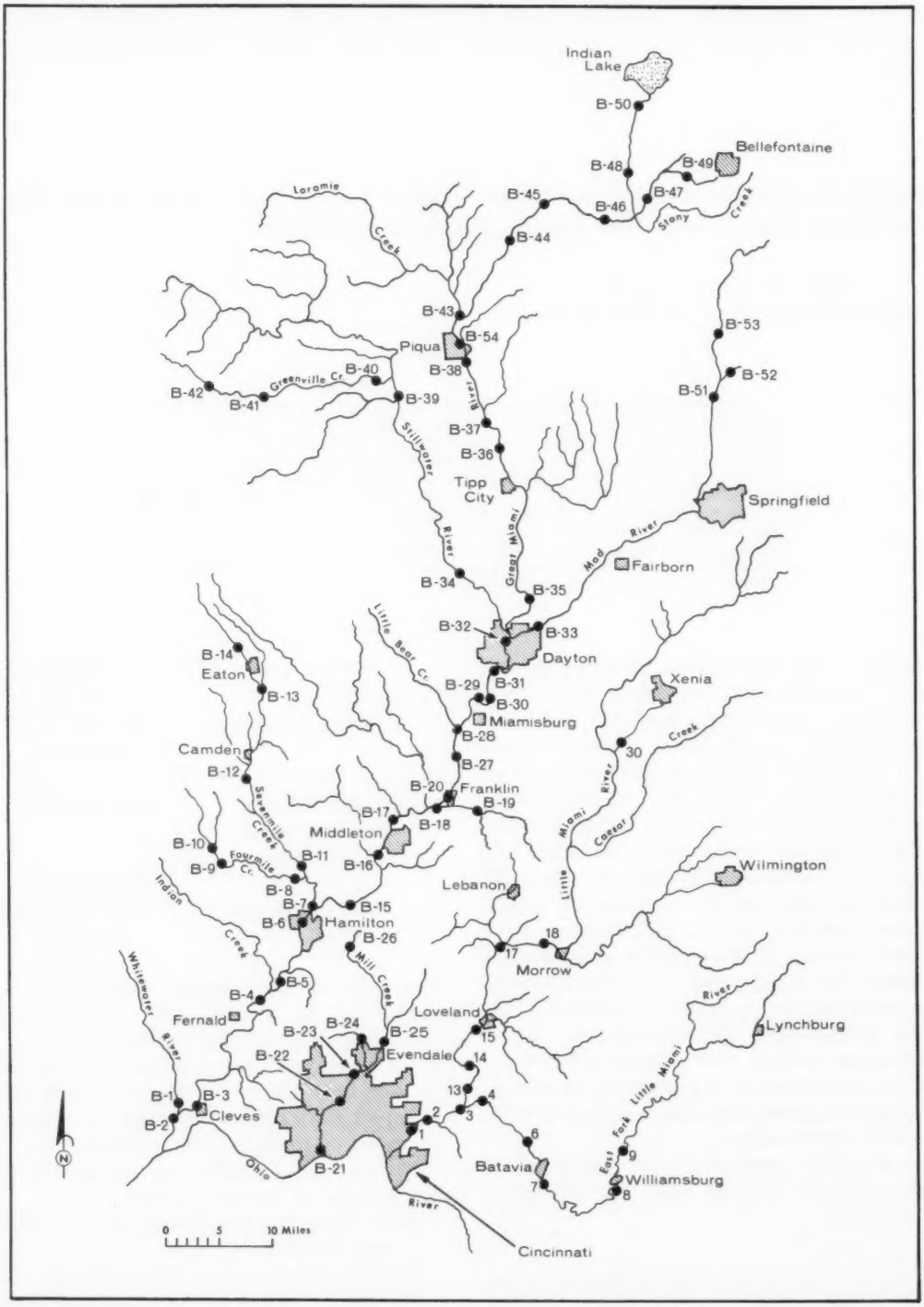

Figure 1. Study area and the general locations of sampling stations

Mound Laboratory and the FMPC routinely discharge liquid radioactive wastes into the Great Miami River. During the development of the aircraft nuclear propulsion project. General Electric used Mill Creek for the disposal of liquid radioactive wastes. However, the status of the General Electric facility since the termination of this project is not known. The one known potential source of liquid radioactive wastes at Wright Patterson Air Force Base is a small reactor facility used for research purposes. Although the manner of disposing of the reactor wastes was not established, the radioactivity level and volume of such wastes would be expected to be quite small in magnitude. Brief descriptions of Mound Laboratory and the FMPC are presented in table 1.

Results

Radionuclide concentrations are summarized in tables 2 and 3. In these tables the format for listing the stations was based on mileage from the stream mouth with the most upstream station listed first. The specific geographical location of each station is shown in figure 1.

The average concentrations of uranium, radium-226, and strontium-90 in the main stem streams are summarized in table 4. In all cases, the average thorium concentration was less than 3 μg/liter. Lead-210 concentrations averaged less than 0.2 pCi/liter in the Little and Great Miami Rivers, with a maximum value of 3.5 pCi/liter at Station B-3 on the Great Miami. The average lead-210 concentration in Mill Creek was 0.7 pCi/liter.

Table 1. Atomic Energy Commission Installations—Great Miami River

Facility and location	Operator	Activity	Prominent radionuclides in radioactive waste
Mound Laboratory Miamisburg, Ohio.	Monsanto Research Corporation.	Polonium and plutonium operations.	Tritium, polonium-210, and plutonium-238.
Feed Materials Production Center.	National Lead Company.	Processing high-grade uranium ores and ore concentrates to produce metallic uranium; and fabrication of the metal into fuel elements. Some thorium processing.	Uranium and radium-228.

Table 2. Dissolved radioactivity in the Little Miami River and Mill Creek[a]

Station number	Location	Uranium[b] (μg/liter)	Radium-226[c] (pCi/liter)	Lead-210[d] (pCi/liter)	Strontium-90[e] (pCi/liter)
	Little Miami River:				
30	Tributary, Glady Run upstream from Spring Valley on county road 144 bridge	0.6	0.03	<0.2	0.4
18	Downstream from Morrow, off U.S. 22 and Ohio 3, at Stubbs Road bridge	.4	.09	<.2	.4
17	Ohio 48 bridge downstream from South Lebanon	.3	.02	<.2	.3
15	Downstream from Loveland at Branch Hill, Guinea Pike bridge	.6	.08	<.2	.4
14	U.S. 50 Bypass and Ohio 126 near Miamiville	.6	.04	<.2	.7
13	Milford bridge at U.S. 50	<.1	.11	<.2	.3
3	Roundbottom Road across from Terrace Park, downstream from the confluence with the East Fork	.1	.09	<.2	.4
2	Newton Road bridge	.5	.15	.4	.8
1	Beechmont bridge	.1	.16	.5	.5
	Little Miami River (East fork):				
9	Upstream from Williamsburg on county road 80 bridge	.6	.05	.6	1.5
8	Downstream from Williamsburg on county road 131 near Ohio 32	.1	.07	—	.3
7	Upstream from Batavia at Ohio 222 bridge	.4	.06	<.2	1.7
6	Downstream from Batavia on Ohio 222	.5	.02	<.2	1.3
4	South Milford at country road 113 bridge	.3	.07	<.2	.8
	Mill Creek:				
B-26	Hamilton-Mason Road bridge	.3	.07	.6	1.2
B-25	U.S. 50 Bypass and Ohio 126 bridge	.2	.05	.5	1.1
B-24	West Fork; Ohio 4, Springfield Pike bridge	.2	.02	.8	1.3
B-23	Ohio 4, Springfield Pike bridge	.3	.01	.9	.7
B-22	Mitchell Avenue bridge	.3	.06	.3	1.0
B-21	Gest Street, Ohio 264	.2	<.01	.8	1.0

[a] Thorium concentrations were <3 μg/liter at all stations except station 9, 3 μg/liter and station 8, 4 μg/liter on the East Fork of the Little Miami River. Analysis performed by the methods in reference (*10*).
[b] Analysis performed by the methods in references (*5,6*).
[c] Analysis performed by the methods in reefrence (*7*).
[d] Analysis performed by the methods in reference (*8*).
[e] Analysis performed by the methods in reference (*9*).

Table 3. Dissolved radioactivity in the Great Miami River and tributary streams[a]

Station number	Location	Distance from mouth of river (miles)	Uranium (μg/liter)	Radium-226 (pCi/liter)	Lead-210 (pCi/liter)	Strontium-90 (pCi/liter)
	Great Miami River:					
B-50	Headwater; Ohio 69 bridge	154.2	1.7	0.19	<0.2	0.9
B-48	County road T-21 near Logansville	147.1	1.3	.06	<.2	.7
B-46	Ohio 69 bridge	140.9	1.3	.21	<.2	.5
B-45	Pasco Road bridge	132.8	1.7	.16	<.2	.5
B-44	Ohio 706 bridge	128.2	.1	.01	<.2	.4
B-43	Piqua Road bridge	119.1	1.7	.11	<.2	.5
B-38	Farrington-Peterson Road bridge	111.6	.9	.13	<.2	<.2
B-37	Troy-Sidney Road bridge	106.6	.6	.10	<.2	.3
B-36	Ohio 41 bridge	105.1	1.0	.08	<.2	.8
B-35	Needmore Road bridge	87.1	1.0	.14	<.2	.5
B-32	South Dayton; U.S. 35	79.8	.4	.20	.4	.5
B-31	Bridge at Moraine, Springboro Pike	77.5	.5	.11	<.2	.4
B-30	Bridge at Dryer, Sellers Road	73.8	.6	.13	<.2	.6
B-29	Carrolton Pike bridge	69.8	.6	.09	.3	.5
B-28	Miamisburg Road bridge	67.3	.8	.12	<.2	.4
B-27	Chautauqua Road bridge	64.7	.3	.22	<.2	.4
B-20	Ohio 123 bridge	60.6	.8	.12	1.2	.4
B-17	Ohio 4 bridge	55.1	.7	.06	<.2	.3
B-16	Ohio 73 bridge	49.4	.9	.06	<.2	.3
B-15	Woodsdale Road bridge (Liberty-Fairfield Road)	43.4	.5	.07	.6	.4
B-6	Ohio 129 bridge in Hamilton	35.3	.8	.03	<.2	.3
B-5	Ohio 128 near Hamilton	32.2	1.1	.05	2.3	.4
B-4	U.S. 50 Bypass and Ohio 126 bridge	25.6	.2	.05	1.1	.2
B-3	U.S. 50 bridge; Cleves	7.8	1.1	.10	3.5	.5
B-2	Elizabeth Town bridge	4.7	.8	.11	.2	.3
	Bokengehalas Creek:					
B-47	County Road T-43 bridge		1.4	.15	<.2	.4
	Bluejacket Creek (Tributary to Bokengehalas Creek):					
B-49	County Road T-31 bridge		1.4	.10	<.2	.4
	Stillwater River:					
B-54	Klinger Road bridge		1.2	.11	1.3	.6
B-39	Falknor Road bridge at Ohio 48		.7	.10	.2	<.2
B-34	Heathcliff Road bridge		1.1	.10	<.2	.3
	Greenville Creek (Tributary to Stillwater River):					
B-42	Daly Road bridge		.3	.08	<.2	<.2
B-41	U.S. 36 bridge		.8	.09	—	<.2
B-40	Gettysburg Road bridge		1.6	.10	<.2	<.2
	Mad River:					
B-53	Ohio 29 bridge		1.4	.15	1.3	<.2
B-51	Ohio 55 bridge		1.1	.14	.4	<.2
B-33	Harshman Road bridge		.6	.19	<.2	.3
	Dugan Run (Tributary to Mad River):					
B-52	County Road 104		1.6	.14	<.2	<.2
	Clear Creek:					
B-19	Ohio 123 bridge		1.1	.15	.3	.5
B-18	Downstream from Franklin sewage treatment plant		.4	.03	.1	.5
	Fourmile Creek:					
B-10	Upstream from Oxford: Ohio 732 bridge		.8	.09	—	.7
B-9	Downstream from Oxford; County Road T-237 bridge		.4	<.01	<.2	.6
B-8	Eaton Road bridge at Warwick Road		1.2	.02	<.2	.6
B-7	At New Miami		.4	.09	<.2	.4
	Sevenmile Creek (Tributary to Fourmile Creek):					
B-14	Washington-Jackson Road bridge		.2	.08	<.2	.3
B-13	U.S. 127 bridge		.7	.09	—	.6
B-12	Downstream from Camden; County Road T-208		.7	.17	—	.6
B-11	U.S. 127 bridge		.8	.06	—	.5
	Whitewater River:					
B-1	Near Elizabeth Town		.7	.10	—	.5

[a] Thorium concentrations were <3 μg/liter at all stations.

Table 4. Average concentrations of uranium, radium-226, and strontium-90 in selected Ohio streams

Location	Uranium (μg/liter)	Radium-226 (pCi/liter)	Strontium-90 (pCi/liter)
Mill Creek	0.3	0.04	1.1
Little Miami River	.4	.08	.7
Great Miami River	.9	.11	.4

Uranium activity ratios (uranium-234/uranium-238) could not be determined for the individual stations because of the low uranium concentrations and small sample volumes. However, for a composite prepared from all the Great Miami River samples, an activity ratio (AR) of 1.24 ± 0.04 was determined. The

excess of uranium-234 is consistent with the findings for freshwater streams (*4*). The activity ratio can be used to convert the mass concentration to an activity concentration by the application of the following relationship:

$$(0.334)\ (\text{uranium concentration, } \mu g/\text{liter})\ (1 + AR) = \text{uranium concentration, pCi/liter}$$

Therefore, for the average mass concentration of 0.9 μg/liter and the AR of 1.24, the average uranium concentration in the Great Miami River, in terms of activity, was less than 1 pCi/liter.

Discussion of results

The concentrations of the naturally-occurring radionuclides (uranium, radium-226, lead-210, and thorium) in the Little Miami River, Great Miami River, and Mill Creek were at low levels. Although there were some differences in the average radionuclide concentrations for the respective streams, these differences were too small to be of practical significance. Similarly, concentration variations in each stream (tables 2 and 3) were typical and consistent with a low background condition.

The batch discharge of liquid wastes from the Feed Materials Production Center to the Great Miami River did not produce any detectable increase in the uranium concentrations at the downstream stations (B-2 and B-3) during the study period. However, the possibility that a more prolonged sampling period might have shown an increase is suggested by the findings of the water monitoring program conducted by the facility contractor, the National Lead Company. For 1967, weekly water sample analyses of the National Lead Company showed an average increase of 5 μg/liter in the uranium concentration of the river as the result of waste releases—9 μg/liter upstream from the FMPC and 14 μg/liter downstream (*11*). The fact that these concentrations are nearly one order of magnitude greater than the 1968 concentrations reported herein is judged to be attributable to differences in the sensitivities of the uranium methods employed by the respective laboratories, not seasonal variations. Liquid waste releases also increased the radium-228 concentration in the river by an estimated 0.3 pCi/liter during 1967 (*11*). (Radium- 228 analyses were not conducted since the presence and prominence of this radionuclide in the FMPC effluent were not known at the time of the field study.)

No attempt was made to quantitate changes in radiological water quality attributable to liquid wastes from the Mound Laboratory. Such changes would be manifest in increased concentrations of tritium, polonium-210, and plutonium-238. However, according to the semiannual reports on the environmental levels of radioactivity in the vicinity of the laboratory, sufficient dilution is available in the Great Miami River to dilute the waste concentrations of radionuclides to levels which are indistinguishable from background levels (*12,13*). For example, during 1967, the reported average concentrations of tritium, polonium, and plutonium at the Chautauqua Road Bridge (station B-27) did not differ from the corresponding upstream or background concentrations. The Chautauqua Road Bridge station is about 1.5 miles below the point of discharge of liquid polonium wastes and about 0.5 miles below the drainage ditch carrying treated tritium and plutonium wastes to the river.

Considering the possibility that the General Electric Company discharges liquid radioactive wastes containing activiation and fission products to Mill Creek, qualitative gamma-ray analyses were performed on the samples from Stations B-23 and B-25, downstream and upstream from the plant site, respectively. Comparison of the gamma spectra and strontium-90 data for both stations did not indicate the presence of a waste source. Although this is not unequivocal support for a conclusion that General Electric does not discharge liquid radioactive wastes to Mill Creek, the negative finding does show that, if liquid discharges are being made, the resultant concentrations are at low levels.

Strontium-90 concentrations were at relatively low levels and in general agreement with the most recently reported monitoring data of the FWPCA, Division of Pollution Surveillance (*14*). During the second and third quarters of 1967, the average strontium-90 concentration

in United States surface waters was about 2 pCi/liter. This average exceeds the specific results of the field study in all cases. On a more localized scale, 1967 second quarter averages for the Little Miami River and the Ohio River at Cincinnati, Ohio, were 1.3 and 1.2 pCi/liter, respectively. Correspondingly, the field study yielded a concentration of only 0.5 pCi/liter for the Little Miami at Cincinnati (station 1). In the absence of atmospheric testing of weapons or other sources of strontium-90, the radiostrontium concentration will decline with time. Although such a trend will be evident over a long period of time (years), the short term variations can be expected to be large since many factors influence the stream concentration (compositing period and procedure, stream flow, etc.). The absolute difference in the 1967 and 1968 results for the Little Miami River is considered to be a short term variation rather than an absolute decrease.

Summarizing, the concentrations of natural radionuclides and strontium-90 in the Great Miami River and Little Miami River were well below the concentration limits for drinking water. All separate radium-226 and strontium-90 concentrations were within the limits of "desirable" criteria recommended by the National Technical Advisory Committee for surface waters used for public water supplies (table 5) (*15*). Uranium concentrations in these rivers closely approached the recommended "desirable" level. Further, the use of the Great Miami River for the ultimate disposal of liquid radioactive wastes from two nuclear installations has not produced any changes in radiological water quality which are of public health significance.

Table 5. Recommended surface water criteria for public water supplies, National Technical Advisory Committee

Constituent	Permissible criteria[a]	Desirable criteria[b]
Uranium	4.4 mg/liter	[c]Absent
Radium-226	3 pCi/liter	<1 pCi/liter
Strontium-90	10 pCi/liter	<2 pCi/liter

[a] Concentrations in raw surface waters which allow the production of a safe, clear, potable, aesthetically pleasing, and acceptable public water supply which meets the limits of the Public Health Service Drinking Water Standards.

[b] Concentrations in raw surface waters which represent high-quality water in all respects for use as public water supplies.

[c] Not detectable by the most sensitive analytical procedure in "Standard Methods" or other approved procedure.

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SECTION I. MILK AND FOOD

Milk Surveillance, December 1971

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of

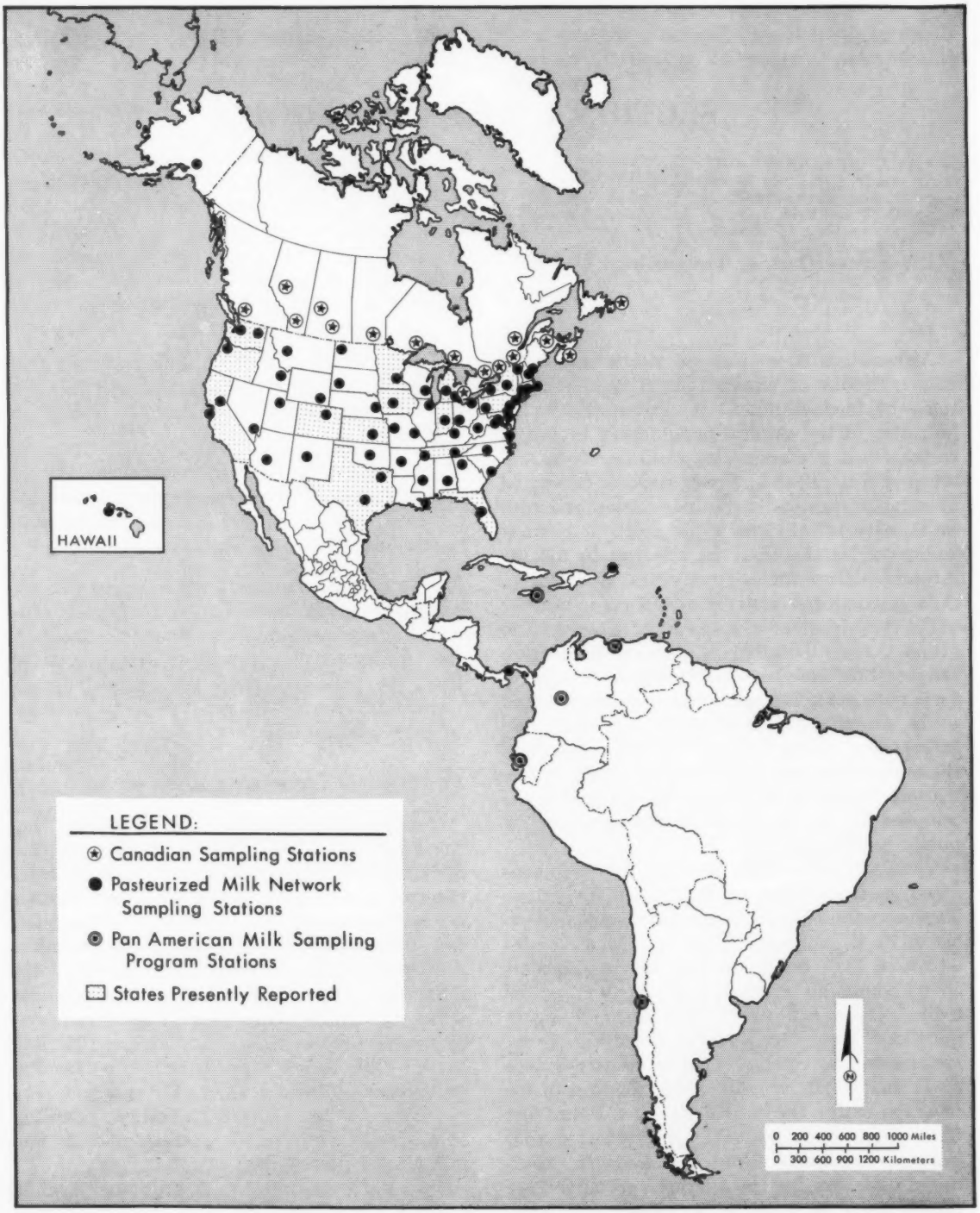

Figure 1. Milk sampling networks in the Western Hemisphere

metabolically similar radionuclides (radiostrontium, and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963-March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during July 1971 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 17 laboratories producing data for the networks reporting in *Radiation Data and Reports*, 14 participated in the experiment.

The accuracy results of this experiment for these 14 laboratories are shown in table 1. Considerable improvement has been made in the accuracy of all radionuclides from those of previous studies. Some improvement is still needed on the strontium-90 results. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A previous article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and an earlier data

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration ±2σ	Number of laboratories in each category			
	Acceptable[a]	Warning level[b]	Unacceptable[c]	Total
Iodine-131 (69 ±6 pCi/liter)	13 (100%)	0	0	13
Cesium-137 (52 ±6 pCi/liter)	12 (92%)	1 (8%)	0	13
Strontium-89 (31 ±6 pCi/liter)	9 (90%)	1 (10%)	0	10
Strontium-90 (41.6 ±2.4 pCi/liter)	9 (69%)	1 (8%)	3 (23%)	13

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

article for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 shows whether raw or pasteurized milk was collected. An analysis (*7*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*7*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the large value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1-5 pCi/liter for levels <50 pCi/liter; 5-10% for levels ≥50 pCi/liter;
Strontium-90	1-2 pCi/liter for levels <20 pCi/liter; 4-10% for levels ≥20 pCi/liter;
Iodine-131, Cesium-137, Barium-140	4-10 pCi/liter for levels <100 pCi/liter; 4-10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was pre-

Table 2. Concentrations of radionuclides in milk for December 1971 and 12-month period, January 1971 through December 1971

Sampling location	Type of sample[a]	Radionuclide concentration (pCi/liter)			
		Strontium-90		Cesium-137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:					
Ala: Montgomery[c]	P	NA	6	13	12
Alaska: Palmer[c]	P	6	4	12	14
Ariz: Phoenix[c]	P	NA	0	0	0
Ark: Little Rock[c]	P	10	12	14	14
Calif: Sacramento[c]	P	NA	1	0	0
San Francisco[c]	P	NA	3	0	0
Del Norte	P	9	13	16	11
Fresno	P	0	2	6	3
Humboldt	P	4	4	13	5
Los Angeles	P	2	2	9	2
Mendocino	P	3	6	10	8
Sacramento	P	2	3	0	3
San Diego	P	0	1	6	3
Santa Clara	P	2	2	7	4
Shasta	P	3	3	8	6
Sonoma	P	2	3	9	6
Colo: Denver[c]	P	NA	5	15	8
East	R	(d)		<0	<0
Northeast	R	(d)		<0	1
Northwest	R	(d)		NS	<0
South central	R	(d)		NS	NS
Southeast	R	(d)		NS	<0
Southwest	R	(d)		<0	2
West	R	(d)		NS	<0
Conn: Hartford[c]	P	NA	7	0	8
Central	P	7	7	14	14
Del: Wilmington[c]	P	NA	8	0	5
D.C: Washington[c]	P	NA	8	0	8
Fla: Tampa[c]	P	5	5	49	43
Central	R	6	7	39	54
North	R	13	10	24	23
Northeast	R	5	7	23	33
Southeast	R	7	11	19	18
Tampa Bay area	P	5	6	36	42
West	R	4	6	44	42
Ga: Atlanta[c]	P	NA	10	0	16
Hawaii: Honolulu[c]	P	2	3	0	2
Idaho: Idaho Falls[c]	P	0	5	0	4
Ill: Chicago[c]	P	5	6	16	9
Ind: Indianapolis[c]	P	NA	7	0	5
Central	P	7	9	10	14
Northeast	P	6	7	10	12
Northwest	P	7	10	10	15
Southeast	P	8	8	10	14
Southwest	P	6	9	15	15
Iowa: Des Moines[c]	P	NA	5	0	3
Iowa City	P	5	7	0	13
Des Moines	P	5 (3)	7	11	12
Little Cedar	P	7	3	11	13
Spencer	P	4	6	12	11
Kans: Wichita[c]	P	NA	7	0	2
Coffeyville	P	7	9	8	15
Dodge City	P	5	6	6	8
Falls City, Nebr	R	NS	4	NS	12
Hays	P	6	10	11	10
Kansas City	P	7	9	12	15
Topeka	P	7	8	7	10
Wichita	P	5	10	13	11
Ky: Louisville[c]	P	NA	9	0	4
La: New Orleans[c]	P	13	14	12	20
Maine: Portland[c]	P	NA	9	12	19
Md: Baltimore[c]	P	NA	8	11	7
Mass: Boston[c]	P	6	8	0	13
Mich: Detroit[c]	P	NA	7	0	10
Grand Rapids[c]	P	NA	8	11	10
Bay City	P	8 (2)	7	7 (2)	15
Charlevoix	P	8 (3)	9	9 (4)	15
Detroit	P	7	7	15	9
Grand Rapids	P	10	7	0	11
Lansing	P	10	8	7 (2)	15
Marquette	P	4	9	24 (2)	23
Monroe	P	0	4	0 (2)	4
South Haven	P	6	6	0 (5)	9
Minn: Minneapolis[c]	P	NA	8	12	14
Bemidji	P	7	9	16	20
Duluth	P	15	17	26	28
Fergus Falls	P	9	8	21	14
Little Falls	P	15	16	26	29
Mankato	P	6	6	0	12
Minneapolis	P	12	19	15	17

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for December 1971 and 12-month period, January 1971 through December 1971—continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—continued						
Minn:	Rochester	P	8	8	11	13
	Worthington	P	7	5	11	0
Miss:	Jackson[c]	P	NA	12	11	10
Mo:	Kansas City[c]	P	NA	8	13	7
	St. Louis[c]	P	NA	6	0	5
Mont:	Helena[c]	P	NA	6	0	10
Nebr:	Omaha[c]	P	NA	7	0	4
Nev:	Las Vegas[c]	P	NA	2	0	1
N.H:	Manchester[c]	P	NA	8	12	19
N.J:	Trenton[c]	P	NA	8	0	9
N. Mex:	Albuquerque[c]	P	NA	3	0	0
N.Y:	Buffalo[c]	P	5	7	11	10
	New York City[c]	P	NA	8	0	11
	Syracuse[c]	P	NA	7	0	8
	Albany	P	7	7	<0	<0
	Buffalo	P	NS		NS	
	Massena	P	<0	6	<0	<0
	New York City	P	7	7	<0	<0
	Syracuse	P	<0	4	NA	
N.C:	Charlotte[c]	P	NA	11	13	12
N. Dak:	Minot[c]	P	NA	9	15	13
Ohio:	Cincinnati[c]	P	NA	7	0	2
	Cleveland[c]	P	NA	7	0	6
Okla:	Oklahoma City[c]	P	NA	6	12	11
Oreg:	Portland[c]	P	3	5	0	6
	Baker	P	NA	3	<0	2
	Coos Bay	P	NA	4	<0	4
	Eugene	P	NA	2	17	3
	Medford	P	NA	2	<0	3
	Portland composite	P	NA	6	NA	6
	Portland local	P	NA	4	<0	8
	Redmond	P	NA	3	<0	2
	Tillamook	P	NA	5	<0	15
Pa:	Philadelphia[c]	P	NA	8	0	6
	Pittsburgh[c]	P	NA	11	0	9
	Dauphin	P	7	8	21	13
	Erie	P	24	9	31	18
	Philadelphia	P	3	7	0	16
	Pittsburgh	P	6	8	18	14
R.I:	Providence[c]	P	NA	8	11	16
S.C:	Charleston[c]	P	10	9	12	14
S. Dak:	Rapid City[c]	P	NA	6	13	6
Tenn:	Chattanooga[c]	P	NA	9	13	10
	Memphis[c]	P	NA	7	11	10
	Chattanooga	P	NA	8	12	15
	Clinton	P	NA	9	21	14
	Fayetteville	P	NA	9	0	9
	Kingston	P	NA	7	6 (2)	10
	Knoxville	P	NA	7	0	11
	Lawrenceburg	R	NA	5	11	4
	Nashville	P	NA	7	11	10
	Pulaski	R	NA	8	15	4
Tex:	Austin[c]	P	NA	1	0	0
	Dallas[c]	P	NA	6	0	4
	Amarillo	R	NA		NA	
	Corpus Christi	R	NA		NA	
	El Paso	R	NA		NA	
	Fort Worth	R	NA		NA	
	Harlingen	R	NA		NA	
	Houston	R	NA		NA	
	Lubbock	R	NA		NA	
	Midland	R	NA		NA	
	San Antonio	R	NA		NA	
	Texarkana	R	NA		NA	
	Uvalde	R	NA		NA	
	Wichita Falls	R	NA		NA	
Utah:	Salt Lake City[c]	P	0	5	0	12
Vt:	Burlington[c]	P	NA	6	0	10
Va:	Norfolk[c]	P	NA	9	0	5
Wash:	Seattle[c]	P	NA	5	0	5
	Spokane[c]	P	NA	6	14	6
	Benton County	R	NS	1	NS	0
	Franklin County	R	0	3	0	5
	Sandpoint, Idaho	R	8	12	22	22
	Skagit County	R	6	8	0	12
W. Va:	Charleston[c]	P	NA	7	11	8
Wisc:	Milwaukee[c]	P	NA	6	0	8
Wyo:	Laramie[c]	P	NA	4	13	2

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for December 1971 and 12-month period, January 1971 through December 1971—continued

Sampling location	Type of sample[a]	Radionuclide concentration (pCi/liter)			
		Strontium-90		Cesium-137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA:					
Alberta: Calgary	P	7	7	18	20
Edmonton	P	6	7	24	24
British Columbia: Vancouver	P	8	9	22	24
Manitoba: Winnipeg	P	6	7	19	22
New Brunswick: Fredericton	P	10	12	14	23
Newfoundland: St. John's	P	17	17	20	31
Nova Scotia: Halifax	P	9	11	14	23
Ontario: Ottawa	P	5	6	5	14
Sault St. Marie	P	11	14	28	33
Thunder Bay	P	11	12	25	25
Toronto	P	4	5	8	13
Windsor	P	4	5	13	11
Quebec: Montreal	P	7	7	19	19
Quebec	P	10	10	25	30
Saskatchewan: Regina	P	7	7	22	16
Saskatoon	P	8	9	16	18
CENTRAL AND SOUTH AMERICA:					
Canal Zone: Cristobal[c]	P	NA	1	0	7
Chile: Santiago	P	0	0	0	2
Colombia: Bogota	P	0	0	0	0
Ecuador: Guayaquil	P	0	0	0	0
Jamaica: Montego Bay	P	NS	5	NS	80
Puerto Rico: San Juan[c]	P	NA	4	0	12
Venezuela: Caracas	P	0	0	0	0
PMN network average[f]		6	7	6	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:
Iodine-131: Colorado—25 pCi/liter Cesium-137: Colorado—25 pCi/liter Strontium-90: New York—3 pCi/liter
Michigan—14 pCi/liter New York—20 pCi/liter
Oregon—15 pCi/liter Oregon—15 pCi/liter

[f] This entry gives the average radionuclides concentrations for the Pasteurized Milk Network stations denoted by footnote [c].

NA, no analysis.
NS, no sample collected.

sented in the December 1970 issue of *Radiological Health Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiation Data and Reports.* The relationship between the PMN stations and the State stations is shown in figure 2. The first column under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average

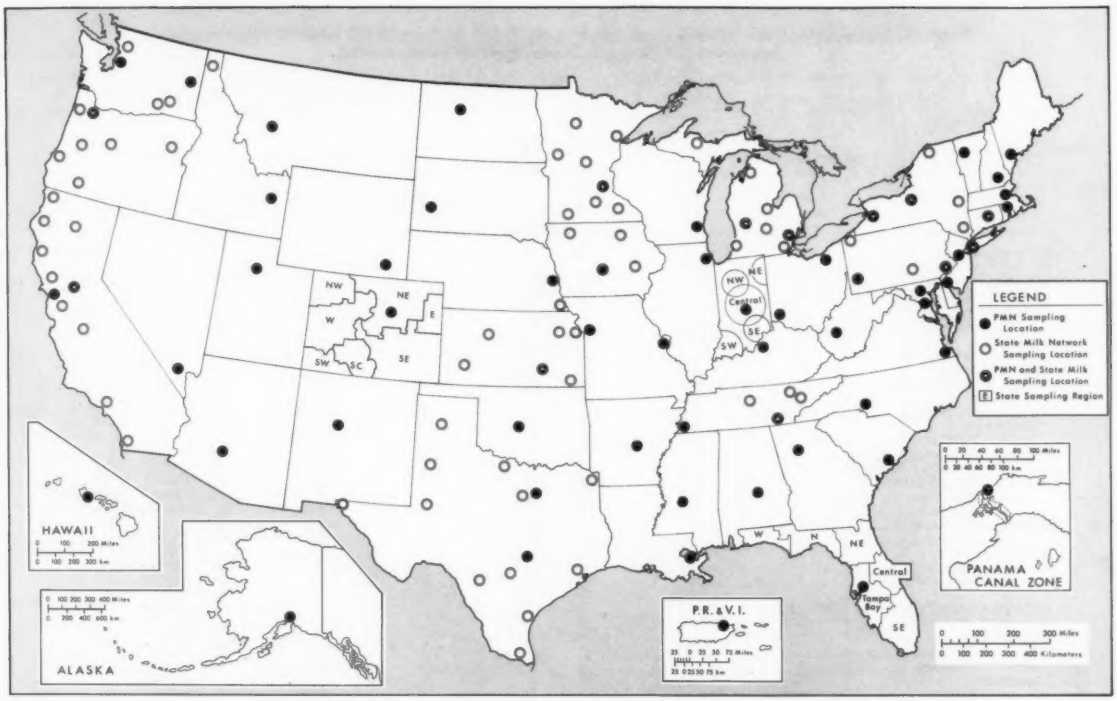

Figure 2. State and PMN milk sampling stations in the United States

for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for December 1971 and the 12-month period, January 1971 to December 1971. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131 and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for December 1971 were below the respective practical reporting levels. The following station averages reflect samples in which strontium-89 was detected: Calif., Del Norte (State) 23 pCi/liter, Humboldt (State) 10 pCi/liter, Mendocino (State) 6 pCi/liter. Iodine-131 and barium-140 were not detected.

Strontium-90 monthly averages ranged from 0 to 24 pCi/liter in the United States for December 1971, and the highest 12-month average was 19 pCi/liter at Minneapolis, Minn. (State), representing 9.5 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 49 pCi/liter in the United States for December 1971, and the highest 12- month average was 54 pCi/liter (Central Florida), representing 1.5 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*8*) and Jamaica.

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data for their milk surveillance networks.

Bureau of Radiological Health
Division of Environmental Sanitation
California State Deportment of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiological Health Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	July-December 1970	November 1971
Carbon-14 in Total Diet and Milk	January-June 1971	December 1971
Connecticut Standard Diet	January-December 1970	December 1971
Strontium-90 in Tri-City Diets	January-December 1970	November 1971

Radiostrontium in Milk, January-December 1970

Health and Safety Laboratory
U.S. Atomic Energy Commission

In 1954, the Health and Safety Laboratory began monitoring for strontium-90 in liquid whole milk to estimate the dietary contribution from the ingestion of the radionuclide from this source.

The New York City sample is a monthly composite of pasteurized milk purchased daily at retail stores. Five main dairies are represented in the sample. The powdered milk sampling at Perry, N.Y. was terminated at the end of 1969.

The strontium-90 to calcium ratios for New York City for January-December is presented in table 1.

[1] Data summarized from "Fallout Program Quarterly Summary Report," HASL-246, January 1, 1972, available from National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January-December 1969	June 1971

Table 1. Strontium-90 to calcium ratios in milk, January–December 1970

Sampling location	Strontium-90 to calcium ratio (pCi /g)											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
New York, N.Y. (liquid whole milk)	8.2	7.0	6.7	7.4	10.0	11.6	11.0	8.5	7.9	7.4	7.2	7.5

Radionuclides in Institutional Diet Samples, July-September 1971

Environmental Protection Agency and
Food and Drug Administration

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. Recognizing that the diet is a potentially significant contribution to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. The program is now administered by the Office of Radiation Programs, Environmental Protection Agency with the assistance of the Office of Food Sanitation, Food and Drug Administration, Department of Health, Education and Welfare (*1*).

This program estimates the dietary intake of radionuclides in a selected population group, ranging from children to young adults of school age. At present, 26 institutions—distributed geographically as shown in figure 1—are being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, but teenage boys consumed 20 percent more food per day (*1,2*). Extrapolating this infor-

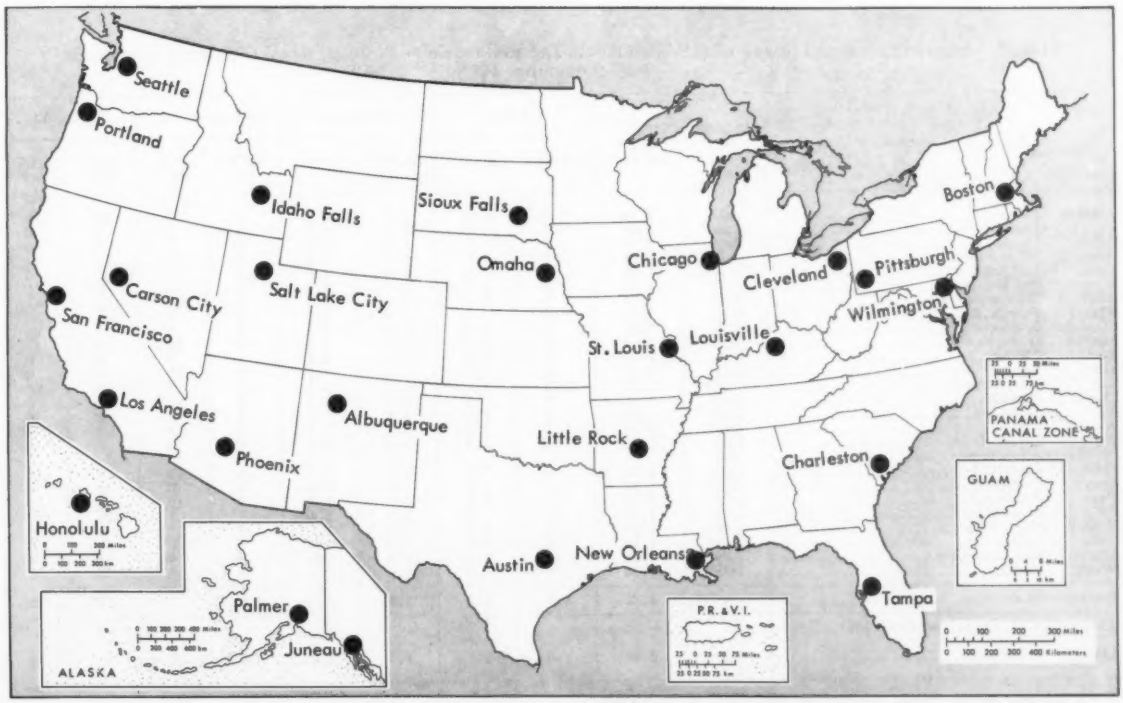

Figure 1. Institutional diet sampling locations as of July–September 1971

mation, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intake of children.

The sampling procedure is generally the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus between-meal snacks) obtained by duplicating the food intake of a different individual daily. Drinking water —which is not included—is also sampled periodically. Each daily sample is kept frozen until the end of the collection period. It is then packed in dry ice and shipped by air to either the Western Environmental Research Laboratory, Las Vegas, Nev.; the Eastern Environmental Radiation Laboratory, Montgomery, Ala.; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures has already been presented in *Radiological Health Data and Reports* (*3*).

Results

Table 1 shows the analytical results for institutional diet samples collected from all stations during July-September 1971. The stable elements, calcium and potassium, are reported in g/kg of diet. Where applicable, radionuclide concentrations of these samples reported in pCi/kg of diet are corrected for radioactive decay to the midpoint of the sample collection period. Dietary intakes in g/day or pCi/day were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.54 kg/day compared to the network average of 1.86 kg/day observed from 1961 through 1970.

Strontium-90 dietary intake averaged 7 pCi/day during this period. Cesium-137 intake averaged 11 pCi/day. These results fall within Range I as defined by the former Federal Radiation Council (*4*). Barium-140 and iodine-131

Table 1. Concentration and intake of stable elements and radionuclides in institutional total diets of children, July–September 1971

Location of Institution		Month[a] (1971)	Total weight (kg/day)	Calcium		Potassium		Strontium-90		Cesium-137	
				(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska:	Juneau	July	1.18	0.7	0.8	1.8	2.1	7	8	19	22
	Palmer	July	1.58	.4	.7	1.3	2.1	5	8	0	0
Ariz:	Phoenix	Sept	1.90	.5	.9	1.1	2.2	0	0	0	0
Ark:	Little Rock	July	1.31	.6	.7	1.8	2.3	8	10	11	14
Calif:	Los Angeles	July[b]	1.83	.3	.6	1.2	2.3	0	0	0	0
	San Francisco	July	1.96	.8	1.5	1.5	3.0	3	7	0	0
Del:	Wilmington	July	2.17	.6	1.4	1.1	2.5	6	14	19	41
Fla:	Tampa	Aug	1.86	.5	.9	1.3	2.4	4	7	19	35
Hawaii:	Honolulu	July	2.27	.5	1.1	1.3	3.1	0	0	11	25
Idaho:	Idaho Falls	July[b]	2.57	.8	2.0	1.7	4.5	6	15	20	51
Ill:	Chicago	July	1.44	.7	1.0	1.7	2.4	5	7	0	0
Ky:	Louisville	July	2.36	.7	1.7	1.6	3.7	7	17	0	0
La:	New Orleans	July[b]	1.97	.6	1.2	1.5	3.0	10	19	14	28
Mass:	Boston	July	1.91	.5	.9	0.9	1.8	6	11	0	0
Mo:	St. Louis	July	1.24	.8	1.0	1.1	1.4	6	7	0	0
Nebr:	Omaha	July[b]	2.11	.8	1.6	1.8	3.8	6	13	0	0
Nev:	Carson City	July	1.64	.7	1.1	1.3	2.2	0	0	0	0
N. Mex:	Albuquerque	NS									
Ohio:	Cleveland	July	1.24	.7	.9	1.3	1.7	8	10	14	17
Oreg:	Portland	July[b]	1.90	.6	1.1	1.6	3.1	3	6	0	0
Pa:	Pittsburgh	July	2.45	.4	1.1	1.1	2.7	5	12	0	0
S.C:	Charleston	July	1.10	.8	.9	1.3	1.4	7	7	18	20
S. Dak:	Sioux Falls	July[b]	1.26	.9	1.1	1.3	1.6	7	8	0	0
Tex:	Austin	July[b]	1.55	.8	1.2	1.4	2.1	0	0	0	0
Utah:	Salt Lake City	July[b]	2.31	.5	1.1	1.3	3.0	0	0	16	37
Wash:	Seattle	July[b]	2.33	.5	1.3	1.5	3.5	0	0	0	0
Institutional average			1.82	0.6	1.1	1.4	2.6	4	7	6	12
ADDENDUM: January—March 1971											
Idaho:	Idaho Falls	Jan[b]	2.30	1.0	2.2	1.7	3.9	12	27	18	41

[a] Quarterly sample usually collected the first month of the quarter.
[b] Food samples were collected from two or more children who were not between the ages of 9 and 12.
Note: Iodine-131 and barium-140 were not detected at any station during this period. Seattle, Wash. had a strontium-89 concentration of 6 pCi/kg.
NS, no sample.

concentrations were below detectable levels. Strontium-89 was detected in Phoenix, Ariz.

All concentrations less than or equal to the appropriate minimum detectable level have been reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the two standard-deviation analytical error. Accordingly, the minimum detectable limits are strontium-89, 5 pCi/kg; strontium-90, 2 pCi/kg; iodine-131, 10 pCi/kg; barium-140, 10 pCi/kg; cesium-137, 10 pCi/kg.

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Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July-September 1970	February 1971
October-December 1970	May 1971
January-March 1971	September 1971
April-June 1971	November 1971

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence [1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	January-December 1969	October 1971
Colorado River Basin	1968	March 1972
Interstate Carrier Drinking Water	1970	July 1971
Kansas	January-December 1970	December 1971
Minnesota	January-June 1970	November 1971
North Carolina	January-December 1967	May 1969
New York	July 1969-June 1970	September 1971
Radioactivity in Florida Waters	1969	January 1972
Tritium in Community Water Supplies	1969	December 1970
Washington	July 1969-June 1970	March 1972

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Gross Radioactivity in Surface Waters of the United States August 1971

Office of Water Programs
U.S. Environmental Protection Agency

The monitoring of gross radioactivity in surface waters of the United States was initiated in 1957, as part of the Water Pollution Surveillance System (formerly National Water Quality Network) of the U.S. Public Health Service. Currently, the program is operated by the U.S. Environmental Protection Agency, Office of Water Programs. Regional offices of the Environmental Protection Agency are responsible for the collection of samples and the entering of the resulting data into the analytical storage and retrieval system. Radioactivity analyses are performed in the centralized radioactivity laboratories of the Office of Water Programs (Cincinnati, Ohio).

The regular reporting of gross radioactivity data in *Radiological Health Data and Reports* was terminated with the publication of data for October 1968 (April 1969 issue). This activity was reinitiated as a monthly report series with the publication of data for January 1971 (September 1971 issue). The unpublished data for the time interval, November 1968 through December 1970, will be the subject of a future summary article.

Table 1 presents the gross alpha and beta results for samples collected from 15 rivers during August 1971. The analytical procedures used for determining gross alpha and beta radioactivity are described in the 13th Edition

Table 1. Gross radioactivity in U.S. surface waters, August 1971

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)				Gross beta radioactivity (pCi/liter)			
		Suspended solids		Dissolved solids		Suspended solids		Dissolved solids	
Animas River:									
Cedar Hills, N. Mex.	1	2		2		8		13	
Bear River:									
Idaho	1	1		2		5		15	
Clinch River:									
Kingston, Tenn.	[a]3	<0.2	(<0.2—<0.2)	<1	(<0.2—1)	1	(1—2)	3	(1—5)
Colorado River:									
above Moab, Colo.	[a]5	6	(1—17)	12	(4—21)	17	(8—41)	33	(13—49)
below Moab, Colo.	[a]5	3	(1—8)	9	(7—12)	15	(5—31)	31	(19—52)
at Silt, Colo.	1	<.1		4		3		10	
Dolores River:									
Bedrock, Colo.	[a]3	7	(1—14)	30	(17—41)	27	(9—42)	80	(70—90)
Gateway, Colo.	[a]4	1	(1—1)	22	(16—28)	10	(6—21)	90	(76—106)
Green River:									
Greendale, Utah	1	<.1		5		2		17	
Gunnison River:									
Grand Junction, Colo.	1	4		12		19		55	
Mississippi River:									
Burlington, Iowa	1	1		1		5		10	
Ohio River:									
Cincinnati, Ohio	[a]4	<.2	(<.2—<.2)	<1	(<.2—1)	3	(2—4)	8	(7—9)
Roanoke River:									
John Kerr Dam, Va.	[a]5	<1	(<.2—1)	<.2	(<.2—<.2)	3	(2—4)	5	(5—6)
San Miguel River:									
above Uravan, Colo.	[a]4	<2	(<.2—2)	4	(2—6)	4	(3—7)	15	(14—16)
below Uravan, Colo.	[a]4	2	(1—4)	13	(10—17)	7	(4—14)	40	(24—59)
at Naturita, Colo.	[a]4	1	(<.2—2)	3	(2—6)	5	(1—11)	15	(12—19)
St Lawrence River:									
Massena, N.Y.	[a]4	<.2	(<.2—<.2)	<1	(<.2—1)	3	(2—4)	6	(5—8)
Susquehanna River:									
Conowingo, Md.	1	<.2		<.2		2		3	
White River:									
Watson, Utah	1	<.2		2		2		11	
Yampa River:									
Maybell, Colo.	1	<.2		2		4		9	

[a] Where more than one sample is analyzed, the minimum and maximum values are in parentheses.

of *Standard Methods for the Examination of Water and Wastewater* (*1*). Results are reported for the date of counting and are not corrected to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards, Handbook 86 (*2*) and is calculated to be <0.2 pCi/liter for gross alpha radioactivity and <1 pCi/liter for gross beta radioactivity measurements.

REFERENCES

(*1*) AMERICAN PUBLIC HEALTH ASSOCIATION, AMERICAN WATER WORKS ASSOCIATION, and WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater, 13th Edition, New York, N.Y. (1971).

(*2*) U.S. DEPARTMENT OF COMMERCE. Radioactivity, recommendations of the International Commission on Radiological Units and Measurements (1962), NBS Handbook 86 (November 29, 1963).

Radiostrontium in Tap Water, January–June 1971

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Health and Safety Laboratory has performed analyses for strontium-90 in tap water at New York City since August 1954. Samples of tap water are collected daily so that by the end of the month a composite of at least 100 liters is available for analysis. Cesium-137 determinations were begun in January 1964. The analytical methods used at the laboratory are given in the Health and Safety Laboratory Manual of Standard Procedures (*1*).

Strontium-90 concentration and cesium-137 to strontium-90 ratios in New York City tap water for January through June 1971 are presented in table 1. These results appear graphically in figure 1.

A decreasing trend has been observed in the strontium-90 concentrations since the July 1963 peak. The maximum strontium-90 concentrations observed are below the acceptable limit as set forth in the interstate carrier drinking water standards (*2*).

[1] Prepared from information appearing in Fallout Program Quarterly Summary Report, HASL–246 (January 1, 1972). This report is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151.

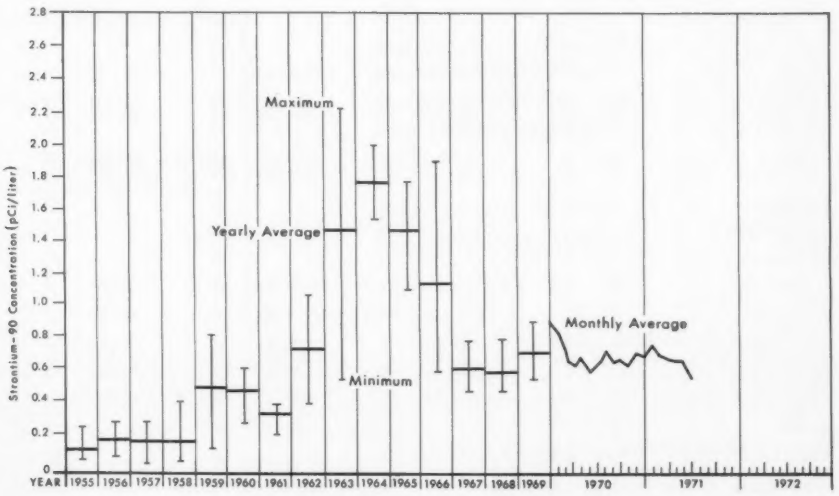

Figure 1. Strontium-90 concentrations in New York City tap water, 1955—June 1971

Table 1. Radiostrontium in New York City tap water, January–June 1971

Sampling months	Strontium-90[a] (pCi/liter)	Cesium-137/ strontium-90
January	0.75	0.09
February	.66	.09
March	.64	.10
April	.63	.11
May	.63	.13
June	.54	NA

[a] Approximately 100 liters per sample.
NA, no analysis.

REFERENCES

(*1*) U.S. ATOMIC ENERGY COMMISSION. Manual of standard procedures 40:E–38–01–16, Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York, N.Y. 10014.

(*2*) FEDERAL REGISTER RULES AND REGULATIONS. Title 42–Public Health, Chapter 1, Public Health Service, Department of Health, Education and Welfare; Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards 27:2154–2155. Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (March 6, 1962).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July-December 1970	October 1971

Tritium Surveillance System, July-September 1971

Office of Radiation Programs
Environmental Protection Agency

The Tritium Surveillance System is an expansion of previous tritium surveillance activities conducted by the Office of Radiation Programs, Environmental Protection Agency (EPA). The principal effort in the past by the Office of Radiation Programs related to tritium releases has been the Tritium in Surface Water Network. This network was established in 1964, to measure and monitor tritium concentrations in major river systems in the United States and to provide surveillance at surface water stations downstream from selected nuclear facilities. The network consisted of selected stations from existing water pollution sampling stations operated by the Office of Water Programs of EPA. The final data from this network for the period January-June 1970, have been published previously (*1*).

Another effort of the Office of Radiation Programs was a tritium in precipitation program. This project was established in 1967 at selected Radiation Alert Network (RAN) stations covering the United States, including Alaska and Hawaii. The RAN is operated by the Office of Air Programs of EPA. The data from this project for July-December 1969, have been published previously (*2*). Due to the increased interest in tritium releases from nuclear facilities and the potential long-term accumulation in the environment, a national system was established to incorporate these projects or networks into one overall system.

Present network

The Tritium Surveillance System consists of 70 quarterly drinking water samples at the RAN stations, precipitation samples collected daily and analyzed monthly from 8 of the RAN stations (figure 1), and quarterly samples at 39 surface water stations (figure 2). The specific locations for the surface water sampling system were determined by examining the water drainage areas to assure that a representative sample from a large area or region was obtained, and if possible, incorporating several nuclear facility sites. All nuclear facilities that were operating, being constructed, or planned through 1975 were considered. Consideration was also given to the current surveillance programs of the States that will be

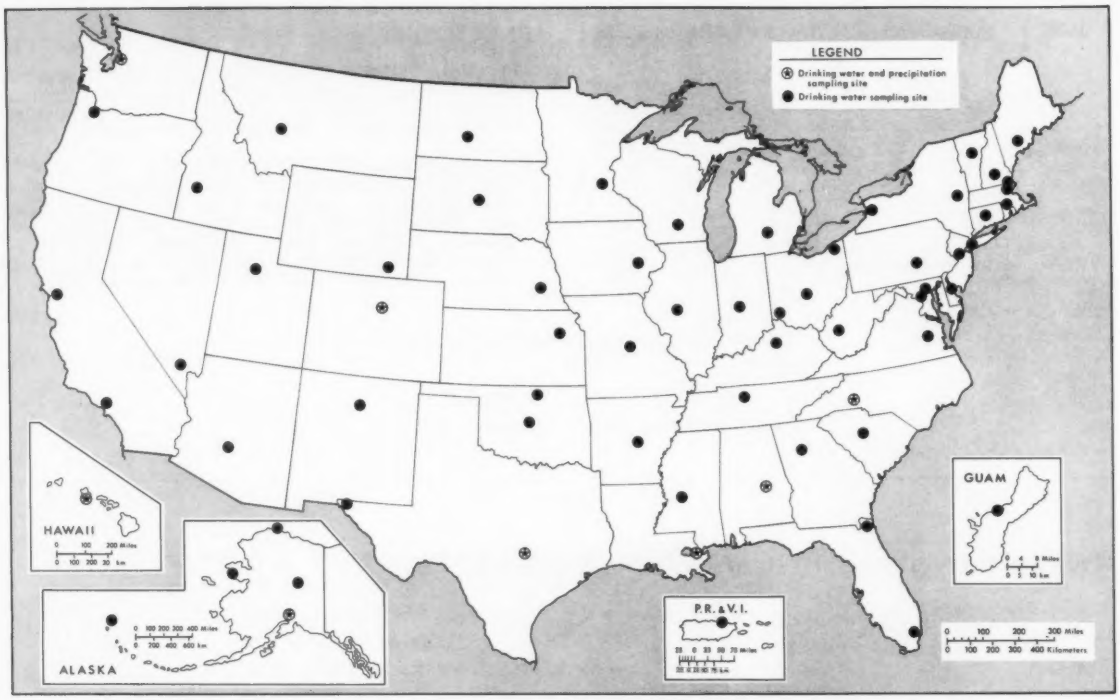

Figure 1. Drinking water and precipitation sampling locations for tritium surveillance system

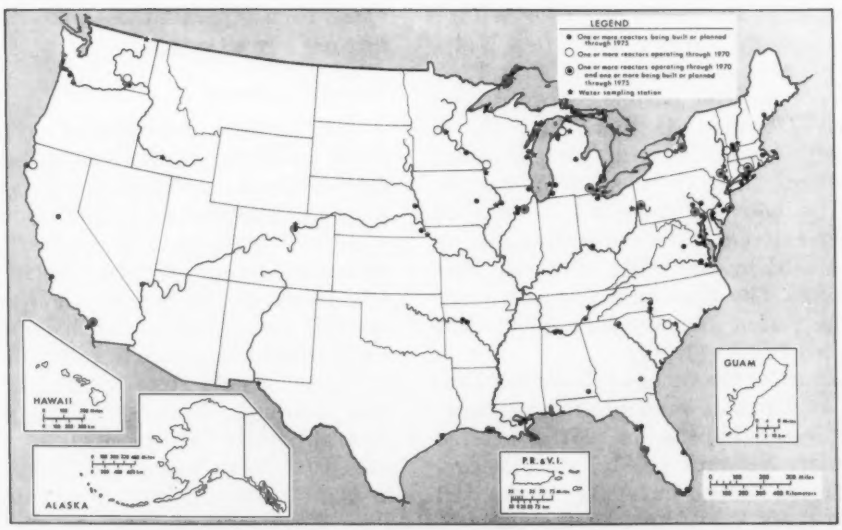

Figure 2. Surface water sampling locations for tritium surveillance system

Table 1. Tritium concentration in tap water (RAN stations) July–September 1971

Location		Date collected	Tritium concentration (nCi/liter ±2σ)
Ala:	Montgomery	7/9	*0
Alaska:	Anchorage	7/2	0
	Attu Island	7/2	0
	Fairbanks	7/8	0
	Juneau	7/19	0
	Kodiak	7/1	0
	Nome	7/30	0.7±0.4
	Point Barrow	NS	
Ariz:	Phoenix	7/1	0
Ark:	Little Rock	7/19	.3± .2
Calif:	Berkeley	7/1	0
	Los Angeles	7/1	0
C.Z:	Ancon	8/5	*0
Colo:	Denver	7/12	1.1± .4
Conn:	Hartford	7/15	0
Del:	Dover	7/12	0
D.C:	Washington	7/26	*0
Fla:	Jacksonville	7/6	*0
	Miami	7/7	*0
Ga:	Atlanta	7/2	.5± .2
Guam:	Agana	7/8	0
Hawaii:	Honolulu	7/1	0
Idaho:	Boise	7/9	0
Ill:	Springfield	7/19	.5± .4
Ind:	Indianapolis	8/6	0
Iowa:	Iowa City	7/2	.6± .4
Kans:	Topeka	7/8	0
Ky:	Frankfort	7/6	.4± .2
La:	New Orleans	7/6	.4± .2
Maine:	Augusta	7/8	0
Md:	Baltimore	7/6	*0
Mass:	Lawrence	7/8	0
	Winchester	7/12	0
Mich:	Lansing	7/12	0
Minn:	Minneapolis	7/6	.7± .4
Miss:	Jackson	7/2	.3± .2
Mo:	Jefferson City	7/1	0
Mont:	Helena	7/6	.7± .4
Nebr:	Lincoln	7/7	0
Nev:	Las Vegas	7/6	1.0± .4
N.H:	Concord	7/8	0
N.J:	Trenton	7/9	0
N. Mex:	Santa Fe	7/1	.5± .4
N.Y:	Albany	7/9	0
	Buffalo	7/12	0
	New York	9/9	0
N.C:	Gastonia	7/6	*0
N. Dak:	Bismarck	7/21	.7± .4
Ohio:	Cincinnati	7/13	.5± .4
	Columbus	7/14	.6± .4
	Painesville	8/4	.6± .4
Okla:	Oklahoma City	7/6	.4± .2
	Ponca City	7/6	*0
Oreg:	Portland	8/12	0
Pa:	Harrisburg	7/15	0
P.R:	San Juan	7/7	*0
R.I:	Providence	7/8	0
S.C:	Columbia	7/7	*0
S. Dak:	Pierre	7/1	1.4± .4
Tenn:	Nashville	7/6	.4± .2
Tex:	Austin	7/7	*0
	El Paso	7/8	*0
Utah:	Salt Lake City	7/8	0
Vt:	Barre	7/8	0
Va:	Richmond	7/12	*0
Wash:	Seattle	7/6	.4± .4
	Spokane	7/1	0
W. Va:	Charleston	7/6	.4± .2
Wisc:	Madison	7/15	1.5± .4
Wyo:	Cheyenne	7/6	1.2± .4
Average[b]			0.2

[a] The minimum detection limit for this sample was 0.2 nCi/liter. All values equal to or less than 0.2 nCi/liter have been reported as zero. For all other numbers, the minimum detection limit was 0.4 nCi/liter and all values equal to or less than 0.4 nCi/liter have been reported as zero.

[b] This is the average of all concentration values as shown in the table. It should be noted that due to varying sensitivities of procedures between the three laboratories, two different minimum detectable concentrations are used.

NS, no sample.

involved in the collection of the samples. The surface water samples are collected quarterly either downstream from a nuclear facility or at a background station.

The tap water samples are collected by the RAN operators on a quarterly basis. The precipitation samples are also collected by the RAN operators on a daily basis.

All samples are sent to one of our laboratories for analysis. Due to the different sensitivity of procedures used by the three laboratories, the minimum detectable concentration varies. Analytical values which are not statistically significant at the 2-sigma confidence level have been reported as zero.

Results and discussion

Table 1 presents the tritium concentrations in drinking water at the RAN stations for July-September 1971. The average tritium concentration was 0.2 nCi/liter.

The radiation dose resulting from the observed tritium concentrations in the drinking water may be evaluated by using the relationship derived by Moghissi and Porter (*3*) from recommendations of the International Commission on Radiological Units and Measurements (*4*). Assuming that the concentration of tritium in all water taken into the body is equal to that found in the drinking water and also that the specific activity of tritium in the body is essentially the same as that in the drinking water, then the radiation dose may be estimated.

The highest individual concentration of tritium observed in the drinking water was 1.5 nCi/liter during the third quarter. This corresponds to a dose of 0.3 mrem/a, or less than 0.2 percent of the Federal Radiation Council's Radiation Protection Guide (170 mrem/a) for an average dose to a suitable sample of the exposed population.

The tritium concentrations for the surface water samples are given in table 2. The highest tritium concentration was 3.9 nCi/liter for the third quarter. Assuming that the specific activity of tritium in the body is essentially the same as that in surface water, this concentration corresponds to a dose of 0.6 mrem/a, or 0.4 percent of the Radiation Protection Guide.

The monthly analyses for tritium in precipitation samples at the 8 RAN stations are shown in table 3.

Table 2. Tritium concentration in surface water, July–September 1971

Location		Water source	Facility	Collection date (1971)	Concentration (nCi/liter ±2σ)
Ala:	Decatur	Tennessee River	Browns Ferry	7/3	0.6±0.2
Ark:	Morrilton	Arkansas River	Arkansas Nuclear	7/19	[a]0
Calif:	Eureka	Humboldt Bay	Humboldt Bay	7/26	0
	San Onofre	Pacific Ocean	San Onofre	7/8	0
Colo:	Greely	South Platte River	Fort St. Vrain	7/11	1.1± .4
Conn:	East Haddam	Connecticut River	Connecticut Yankee and Vermont Yankee	7/22	.8± .4
	Waterford	Long Island Sound	Millstone	7/22	0
Fla:	Crystal River	Gulf of Mexico	Crystal River	9/22	[a]0
	Homestead	Biscayne Bay	Turkey Point	9/22	[a]0
Idaho:	Buhl	Snake River	National Reactor Testing Station	7/9	0
Ill:	Moline	Mississippi River	Quad-Cities	7/22	0
	Morris	Illinois River	Dresden and Argonne	7/26	.5± .4
La:	New Orleans	Mississippi River	(Several)	7/12	.5± .2
Md:	Conowingo	Susquehanna River	Peach Bottom and Three-Mile-Island	7/14	.5± .4
	Lusby	Chesapeake Bay	Calvert Cliffs	7/20	0
Mass:	Rowe	Deerfield River	Yankee	7/15	3.8± .4
Mich:	Charlevoix	Lake Michigan	Big Rock Point	8/14	0
	Monroe	Lake Erie	Enrico Fermi	8/16	.6± .4
	South Haven	Lake Michigan	Palisades	8/9	0
Minn:	Monticello	Mississippi River	Monticello	7/6	.6± .4
Nebr:	Rulo	Missouri River	Fort Calhoun and Cooper	7/1	.9± .4
Nev:	Boulder City	Colorado River	Background	7/6	1.3± .4
N.J:	Bayside	Delaware River	Salem	7/7	0
N.Y:	Ossining	Hudson River	Indian Point	8/2	.7± .4
	Oswego	Lake Ontario	Nine Mile Point and R. E. Ginna	7/12	0
	Poughkeepsie	Hudson River	Background	7/21	0
N.C:	Charlotte	Catawba River	Wm. B. McGuire	9/16	.5± .2
Oreg:	Westport	Columbia River	Rainier and Hanford	8/24	.6± .4
S.C:	Allendale	Savannah River	Savannah River Plant and Oconee	7/10	3.9± .2
	Hartsville	Lake Robinson	H. B. Robinson	9/18	.6± .2
Tenn:	Kingston	Clinch River	Oak Ridge	7/27	1.9± .2
Tex:	El Paso	Rio Grande River	Los Alamos	7/6	.6± .4
Vt:	Vernon	Connecticut River	Vermont Yankee	7/12	0
Va:	Newport News	James River	Surry	7/10	.3± .2
Wash:	Northport	Columbia River	Background	7/16	.7± .4
	Pasco	Columbia River	Hanford	7/2	.8±.4
W. Va:	Wheeling	Ohio River	Shippingport	7/13	0
Wisc:	Two Creeks	Lake Michigan	Point Beach and Kewaunee	7/19	0
	Victory	Mississippi River	LaCrosse and Prairie Island	7/15	.6± .4
Average[b]					0.6

[a] The minimum detection limit for this sample was 0.2 nCi/liter. All values equal to or less than 0.2 nCi/liter have been reported as zero. For al other numbers, the minimum detection limit was 0.4 nCi/liter and all values equal to or less than 0.4 nCi/liter have been reported as zero.
[b] This is the average of all concentration values as shown in the table. It should be noted that due to varying sensitivities of procedures between the three laboratories, two different minimum detectable concentrations are used.

Table 3. Tritium concentration in precipitation from RAN stations, July–September 1971

Location		Tritium concentration[a] (nCi/liter ±2 σ)		
		July	August	September
Ala:	Montgomery	0.4±0.2	0.8±0.2	0
Alaska:	Anchorage	.6± .2	NS	0
Colo:	Denver	1.2± .2	.7± .2	0.7±0.2
Hawaii:	Honolulu	0	0	0
La:	New Orleans	0	NS	0
N.C:	Gastonia	.3± .2	0	NS
Tex:	Austin	NS	NS	NS
Wash:	Seattle	.7± .2	.3± .2	0

[a] The minimum detection limit for these samples was 0.2 nCi/liter. All values equal to or less than 0.2 nCi/liter have been reported as zero.
NS, no sample.

Other coverage in *Radiological Health Data and Reports:*

Period	Issue
July-December 1970	May 1971
January-March 1971	July 1971
April-June 1971	November 1971

REFERENCES

(1) BUREAU OF RADIOLOGICAL HEALTH. Tritium in surface water network, January-June 1970. Radiol Health Data Rep 11:638–639 (November 1970).

(2) BUREAU OF RADIOLOGICAL HEALTH. Tritium in precipitation (RAN), July-December 1969. Radiol Health Data Rep 11:354–355 (July 1970).

(3) MOGHISSI, A. A. and C. R. PORTER. Tritium in surface waters in the United States, 1966. Radiol Health Data Rep 9:337–339 (July 1968).

(4) INTERNATIONAL COMMISSION ON RADIOLOGICAL UNITS AND MEASUREMENTS. Recommendations of the International Commission of Radiological Units and Measurements, National Bureau of Standards Handbook 85 (1964).

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the California State Department of Public Health, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports:*

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	January-December 1970	December 1971
Mexican Air Monitoring Program	August-December 1970 and January 1971	October 1971
Plutonium in Airborne Particulates	April-June 1971	March 1972
Surface Air Sampling Program 80th Meridian Network, *HASL*	January-December 1969	February 1972

1. Radiation Alert Network December 1971

Division of Atmospheric Surveillance
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Air Quality Information Systems Branch, Division of Atmospheric Surveillance, EPA, Research Triangle Park, North Carolina 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during December 1971.

All field estimates reported were within normal limits for the reporting station.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, December 1971

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Number of samples	Total depth (mm)	Precipitation		
								Field estimation of deposition		
			Maximum	Minimum	Average[a]			Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	21	2	0	1	5	56	5	56	18
Alaska:	Anchorage	2	0	0	0	0				
	Attu Island	30	0	0	0	0				
	Fairbanks	0				0				
	Juneau	0				0				
	Kodiak	0				0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	14	10	3	5	0				
Ark:	Little Rock	0				0				
Calif:	Berkeley	12	1	0	0	8	104	8	104	0
	Los Angeles	23	3	0	1	0				
C.Z:	Ancon	17	0	0	0	0				
Colo:	Denver	22	5	1	2	1	1	[b]		
Conn:	Hartford	18	0	0	0	5	39	5	39	0
Del:	Dover	20	1	0	0	0				
D.C:	Washington	14	1	0	0	0				
Fla:	Jacksonville	19	1	0	0	4	92	2	31	0
	Miami	17	0	0	0	3	60	2	60	0
Ga:	Atlanta	22	2	0	1	0				
Guam:	Agana	0				0				
Hawaii:	Honolulu	21	1	0	0	3	52	[b]		
Idaho:	Boise	21	1	0	0	8	38	8	38	0
Ill:	Springfield	11	2	0	1	0				
Ind:	Indianapolis	20	1	0	0	0				
Iowa:	Iowa City	20	1	0	1	3	78	3	78	0
Kans:	Topeka	20	2	0	1	6	57	6	57	7
Ky:	Frankfort	0				0				
La:	New Orleans	19	0	0	0	7	144	[b]		
Maine:	Augusta	19	0	0	0	6	35	6	35	0
Md:	Baltimore	20	1	0	0	2	12	2	12	0
Mass:	Lawrence	20	0	0	0	5	48	5	48	0
	Winchester	19	1	0	0	7	36	7	36	0
Mich:	Lansing	19	1	0	0	0				
Minn:	Minneapolis	20	1	0	0	4	10	4	10	2
Miss:	Jackson	16	1	0	0	7	207	7	207	0
Mo:	Jefferson City	21	2	0	1	8	110	8	110	0
Mont:	Helena	20	2	0	1	1	13	1	13	0
Nebr:	Lincoln	19	8	1	2	1	1	1	1	0
Nev:	Las Vegas	16	5	0	2	0				
N.H:	Concord	0				0				
N.J:	Trenton	21	1	0	0	6	28	6	28	1
N. Mex:	Santa Fe	16	1	0	0	0				
N.Y:	Albany	23	1	0	0	0				
	Buffalo	19	1	0	0	0				
	New York City	0				0				
N.C:	Gastonia	17	5	1	2	0		[b]		
N. Dak	Bismarck	22	2	0	1	4	11	4	11	1
Ohio:	Cincinnati	0				0				
	Columbus	3	1	0	0	0				
	Painesville	21	1	0	0	7	50	7	50	11
Okla:	Oklahoma City	0				0				
	Ponca City	21	2	0	1	7	75	7	75	0
Oreg:	Portland	21	1	0	0	15	225	15	225	10
Pa:	Harrisburg	15	1	0	0	0				
P.R:	San Juan	0				0				
R.I:	Providence	22	1	0	0	0				
S.C:	Columbia	13	2	0	1	3	68	3	68	0
S. Dak:	Pierre	21	4	0	1	0				
Tenn:	Nashville	18	1	0	0	11	120	11	120	2
Tex:	Austin	14	4	0	1	6	87	[b]		
	El Paso	5	2	1	1	0				
Utah:	Salt Lake City	28	1	0	0	10	20	10	20	0
Vt:	Barre	18	1	0	0	8	41	8	41	3
Va:	Richmond	22	1	0	0	1	2	1	2	1
Wash:	Seattle	9	0	0	0	9	116	[b]		
	Spokane	21	1	0	0	0				
W. Va:	Charleston	20	2	0	1	6	32	6	32	6
Wisc:	Madison	23	1	0	0	7	96	7	96	6
Wyo:	Cheyenne	23	5	0	2	0				
Network summary		1,048	10	0	1	193	75	6	59	2

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

2. Canadian Air and Precipitation Monitoring Program,[1] December 1971

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1-5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for December 1971 are presented in table 2.

[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, December 1971

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	23	0.2	0.0	0.1	NS	NS
Coral Harbour	23	.1	.0	.1	6	0.3
Edmonton	23	.2	.0	.1	8	.4
Ft. Churchill	24	.1	.0	.1	28	.3
Fredericton	21	.1	.0	.1	19	1.2
Goose Bay	24	.1	.0	.1	8	.4
Halifax	24	.2	.0	.1	14	1.7
Inuvik	24	.1	.0	.1	31	.4
Montreal	24	.1	.0	.0	20	1.7
Moosonee	24	.1	.0	.1	4	.2
Ottawa	24	.1	.0	.1	21	1.8
Quebec	24	.1	.0	.1	7	.8
Regina	23	.2	.1	.1	40	.6
Resolute	24	.1	.1	.1	36	.1
St. John's, Nfld	24	.2	.0	.0	17	.9
Saskatoon	24	.1	.1	.1	11	.4
Sault Ste. Marie	NS				16	1.5
Thunder Bay	24	.4	.0	.1	17	.7
Toronto	24	.4	.0	.1	14	1.3
Vancouver	24	.3	.0	.0	12	2.4
Whitehorse	24	.1	.0	.1	18	.6
Windsor	24	.2	.0	.0	18	2.0
Winnipeg	24	.2	.0	.1	43	.3
Yellowknife	24	.2	.1	.1	11	.1
Network summary	545	0.4	0.0	0.1	17	0.8

NS, no sample.

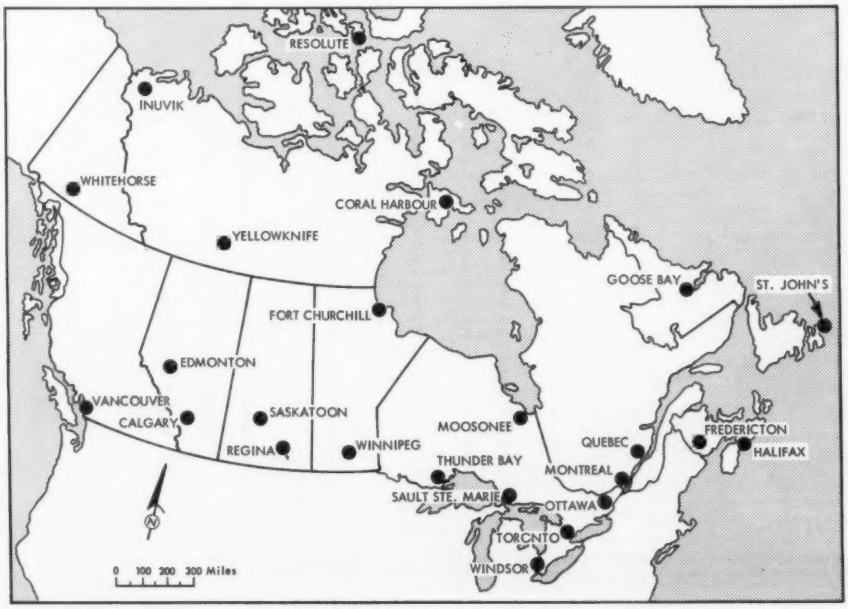

Figure 2. Canadian air and precipitation sampling stations

3. Pan American Air Sampling Program December 1971

Pan American Health Organization and Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The December 1971 air monitoring results from the participating countries are given in table 3.

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, December 1971

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	10	0.11	0.02	0.06
Chile:	Santiago	30	.38	.03	.20
Colombia:	Bogota	20	.06	.00	.02
Ecuador:	Cuenca	6	.03	.01	.02
	Guayaquil	9	.29	.11	.19
	Quito	7	.03	.01	.02
Guyana:	Georgetown	10	.03	.00	.01
Jamaica:	Kingston	0			
Peru:	Lima	0			
Venezuela:	Caracas	10	.05	.01	.02
West Indies:	Trinidad	5	.02	.01	.02
Pan American summary		107	0.38	0.00	0.09

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

4. California Air Sampling Program December 1971

Bureau of Radiological Health
California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 4.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where they are analyzed for their radioactive content.

Airborne particles are collected by a continuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size,

Figure 4. California Air Sampling Program stations

using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity. Analyses are normally made 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample. A gamma-scan and an analysis for strontium-89 and strontium-90 are made. Table 4 presents the monthly gross beta radioactivity in air for the month of December 1971.

Table 4. Gross beta radioactivity in California air December 1971

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	31	0.87	0.00	0.23
Barstow	31	.77	.06	.25
Berkeley	30	.68	.00	.18
Colfax	31	.44	.00	.12
El Centro	31	.87	.07	.33
Eureka	29	.33	.03	.10
Fresno	31	1.16	.03	.21
Los Angeles	31	.43	.06	.18
Redding	30	.47	.03	.12
Sacramento	26	.79	.00	.21
Salinas	31	1.44	.02	.30
San Bernardino	10	.30	.09	.21
San Diego	31	.35	.02	.15
Santa Rosa	25	.71	.02	.16
Summary	398	1.44	0.00	0.20

5. Plutonium in Airborne Particulates July–September 1971

Office of Radiation Programs
Environmental Protection Agency

The Radiation Alert Network (RAN) of the Office of Air Programs, Environmental Protection Agency, routinely collects airborne particulate samples from eleven selected RAN stations for plutonium analyses. The plutonium analyses were initiated in November 1965 and references to the previous results through December 1969 have been published (*6*).

One-half of each individual air filter from the selected stations is sent to the Northeastern Radiological Health Laboratory, Winchester, Mass. The laboratory analyzes a composite of these samples for each station on a quarterly basis. The results for July-September 1971 are presented in table 5. The minimum detectable activities are 0.020 pCi and 0.015 pCi per samples for plutonium-238 and plutonium-239, respectively. The volume of air samples varies, generally ranging from 20,000 to 30,000 cubic meters per month.

Other coverage in *Radiation Data and Reports:*

Period	Issue
January-June 1970	March 1971
July-December 1970	June 1971
January-March 1971	November 1971
April-June 1971	March 1972

Table 5. Plutonium in airborne particulates July–September 1971

Location		Plutonium-238 (aCi/m³)	Plutonium-239 (aCi/m³)	$^{239}Pu/^{238}Pu$
Alaska:	Anchorage	ND	11 ±2	
Ariz:	Phoenix	7 ±3	58 ±11	8 ±4
Colo:	Denver	2 ±1	66 ±5	33 ±17
Hawaii:	Honolulu	ND	40 ±4	
La:	New Orleans	ND	28 ±3	
Md:	Baltimore	2 ±1	62 ±5	31 ±16
N.Y:	Buffalo	5 ±2	84 ±9	17 ±7
N.C:	Gastonia	ND	53 ±3	
S. Dak:	Pierre	4 ±1	79 ±6	20 ±5
Tex:	Austin	NS		
Wash:	Seattle	3 ±1	42 ±5	14 ±5

ND, nondetectable.
NS, no sample.

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(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4. Deportment of National Health and Welfare, Ottawa, Canada (December 1961).

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(*6*) BUREAU OF RADIOLOGICAL HEALTH. Plutonium in airborne particulates, April-December 1969. Radiol Health Data Rep 11:552–553 (October 1970).

Air Surveillance Network, October-November 1971

Western Environmental Research Laboratory
Environmental Protection Agency
Las Vegas, Nev.

The Air Surveillance Network (ASN), operated by the Western Environmental Research Laboratory (WERL), consists of 104 active and 18 standby sampling stations located in 21 western States (figures 1 and 2). The network is operated in support of nuclear testing conducted by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), at the Nuclear Rocket Development Station which lies adjacent to the NTS, and at any other western testing sites designated by the AEC.[1]

The stations are operated by State health department personnel and by private individ-

[1] The ASN is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

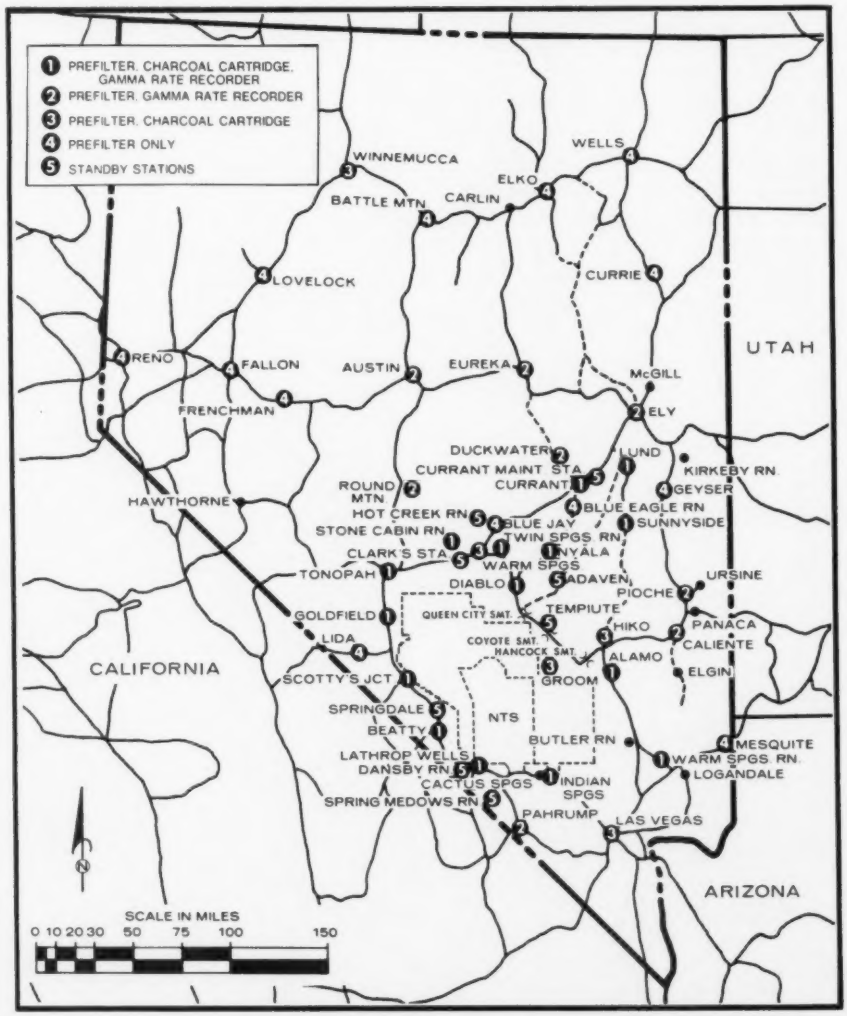

Figure 1. WERL Air Surveillance Network stations in Nevada

Figure 2. WERL Air Surveillance Network stations outside Nevada

uals on a contract basis. All samples are mailed to the WERL unless special retrieval is arranged at selected locations in support of known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports*.

Results

Table 1 presents the monthly average gross beta radiation in air particulates during October 1971; table 2 presents the data for November 1971. The minimum reporting concentration for gross beta radioactivity is 0.1 pCi/m³. For averaging purposes individual concentrations which are below the minimum detectable concentration (0.06-0.07 pCi/m³) are assumed to be equal to the minimum detectable concentration. Averages less than the minimum reportable level (0.1 pCi/m³) are reported as <0.1 pCi/m³.

No radionuclides were identified by gamma spectrometry on any filters collected during October. No radioactivity was identified on any of the charcoal cartridges.

From gamma spectrometry results, fresh fission products in varying combinations of cerium-141, tellurium-132, iodine-131, and barium-140 were identified on filters collected in Arizona, California, Colorado, Idaho, Louisiana, Missouri, Nebraska, Nevada, New Mexico, Texas, Utah, and Wyoming during November. The highest concentrations of these radionuclides respectively, were 1.4 pCi/m³ (Reno), 2.0 pCi/m³ (Winnemucca), 2.4 pCi/m³ (Reno), and 3.3 pCi/m³ (Reno). These radionuclides and higher than normal gross beta concentrations may have resulted from a non-U.S. nuclear test conducted on November 18, 1971.

Table 1. Summary of gross beta radioactivity concentrations in air, October 1971

Location		Number of samples	Concentration[a] (pCi/m³)		
			Maximum	Minimum	Average
Ariz:	Kingman	30	0.4	0.1	0.2
	Phoenix	31	.4	<.1	.2
	Seligman	31	.5	<.1	.2
	Winslow	31	.6	<.1	.2
Ark:	Little Rock	11	.7	<.1	.2
Calif:	Baker	27	.3	<.1	.2
	Barstow	31	.3	<.1	.2
	Bishop	31	.4	<.1	.2
	Death Valley Junction	30	.3	<.1	.2
	Furnace Creek	30	.3	<.1	.2
	Indio	31	.5	<.1	.2
	Lone Pine	23	.4	.1	.2
	Needles	27	.3	<.1	.2
	Ridgecrest	31	.2	<.1	.2
	Shoshone	31	.4	<.1	.2
Colo:	Denver	19	.2	<.1	.1
	Durango	31	.3	<.1	.2
Idaho:	Boise	31	.3	<.1	.1
	Idaho Falls	20	.2	<.1	.1
	Preston	31	.3	<.1	.1
	Twin Falls	31	.3	<.1	.1
Iowa:	Iowa City	20	<.5	<.1	.1
	Sioux City	27	.3	.1	.1
Kans:	Dodge City	31	.2	<.1	.1
La:	Lake Charles	16	.3	.1	.1
	Monroe	19	.3	<.1	.1
	New Orleans	21	.3	.1	.1
Minn:	Minneapolis	18	.2	.1	.1
Mo:	Joplin	30	.2	<.1	.1
	St. Joseph	31	.3	<.1	.1
	St. Louis	30	.5	<.1	.2
Nebr:	North Platte	25	.3	.1	.2
Nev:	Alamo	31	.5	<.1	.2
	Austin	24	.3	.1	.1
	Battle Mountain	29	.2	<.1	.1
	Beatty	31	.3	.1	.2
	Blue Eagle Ranch (Currant)	30	.5	<.1	.2
	Blue Jay	31	.5	<.1	.2
	Caliente	31	.3	<.1	.2
	Currant Ranch	28	.2	<.1	.1
	Currie	31	.4	<.1	.2
	Diablo	31	.3	<.1	.2
	Duckwater	26	.3	<.1	.1
	Elko	31	.2	<.1	.1
	Ely	28	.3	<.1	.2
	Eureka	30	.4	<.1	.2
	Fallini's Twin Springs Ranch	31	.4	.1	.2
	Fallon	31	.3	<.1	.2
	Frenchman Station	31	.3	<.1	.2
	Geyser Maintenance Station	27	.3	<.1	.1
	Goldfield	30	.3	<.1	.2
	Groom Lake	30	.5	<.1	.2
	Hiko	31	.4	<.1	.2
	Indian Springs	31	.3	<.1	.2
	Las Vegas	17	.3	.1	.2
	Lathrop Wells	30	.3	<.1	.2
	Lida	30	.3	.1	.2
	Lovelock	31	.3	<.1	.1
	Lund	26	.4	<.1	.2
	Mesquite	31	.4	.1	.2
	Nyala	31	.4	.1	.2
	Pahrump	18	.3	.1	.1
	Pioche	31	.3	<.1	.1
	Reno	30	.2	<.1	.1
	Round Mountain	28	.3	.1	.2
	Scotty's Junction	31	.3	.1	.2
	Stone Cabin Ranch	31	.3	<.1	.2
	Sunnyside	13	.3	<.1	.1
	Tonopah	30	.3	<.1	.2
	Tonopah Test Range	28	.4	<.1	.2
	Warm Springs Ranch	31	.3	<.1	.1
	Wells	31	.3	<.1	.1
	Winnemucca	31	.3	<.1	.1
N. Mex:	Albuquerque	21	.4	<.1	.2
	Carlsbad	31	.6	<.1	.2
Okla:	Muskogee	28	.3	.1	.1
Oreg:	Burns	31	.2	<.1	.1
	Medford	18	.2	.1	.1
S. Dak:	Aberdeen	31	.4	<.1	.1
	Rapid City	29	.2	<.1	.1
Tex:	Abilene	28	.4	<.1	.2
	Amarillo	31	.5	<.1	.2
	Austin	7	.2	.1	.1
	Fort Worth	29	.4	<.1	.2
Utah:	Bryce Canyon	22	.2	<.1	.1
	Cedar City	30	.3	<.1	.1
	Delta	31	.3	<.1	.2
	Dugway	31	.3	<.1	.2

Table 1. Summary of gross beta radioactivity concentrations in air, October 1971 —continued

Location		Number of samples	Concentration[a] (pCi/m³)		
			Maximum	Minimum	Average
Utah:	Enterprise	31	.4	<.1	.1
	Garrison	31	.4	<.1	.2
	Logan	30	.3	.1	.2
	Milford	31	.5	<.1	.2
	Monticello	22	.2	<.1	.1
	Parowan	31	.3	<.1	.1
	Provo	29	.3	<.1	.1
	Roosevelt	31	.3	<.1	.1
	Salt Lake City	31	.3	.1	.1
	St. George	32	.3	<.1	.2
	Wendover	31	.3	<.1	.2
Wash:	Seattle	19	.1	<.1	.1
	Spokane	17	.1	<.1	.1
Wyo:	Rock Springs	31	.3	<.1	.1
	Worland	31	.2	<.1	.1

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m³ is reported as <0.1 pCi/m³.

Table 2. Summary of gross beta radioactivity concentrations in air, November 1971

Location		Number of samples	Concentration[a] (pCi/m³)		
			Maximum	Minimum	Average
Ariz:	Kingman	30	18.0	<0.1	1.5
	Phoenix	29	3.0	<.1	.5
	Seligman	30	14.0	.1	1.1
	Winslow	30	7.8	<.1	.6
Ark:	Little Rock	10	.7	<.1	.2
Calif:	Baker	24	15.0	<.1	1.1
	Barstow	30	32.0	<.1	1.5
	Bishop	29	31.0	<.1	2.4
	Death Valley Junction	28	6.4	<.1	.4
	Furnace Creek	28	.9	<.1	.2
	Indio	30	4.9	<.1	.5
	Lone Pine	26	16.0	.1	1.2
	Needles	24	11.0	<.1	.8
	Ridgecrest	30	7.1	<.1	.6
	Shoshone	31	8.1	<.1	.6
Colo:	Denver	22	1.1	.1	.3
	Durango	30	3.2	<.1	.3
Idaho:	Boise	29	3.3	<.1	.3
	Idaho Falls	21	2.9	.1	.3
	Preston	28	4.7	.1	.4
	Twin Falls	29	3.7	<.1	.3
Iowa:	Iowa City	18	.5	.1	.1
	Sioux City	26	.4	<.1	.1
Kans:	Dodge City	29	1.1	.1	.1
La:	Lake Charles	19	1.1	.1	.2
	Monroe	13	.3	.1	.1
	New Orleans	19	.7	.1	.2
Minn:	Minneapolis	20	.2	<.1	.1
Mo:	Joplin	30	.8	<.1	.2
	St. Joseph	30	1.4	<.1	.2
	St. Louis	30	.2	.1	.1
Nebr:	North Platte	25	1.5	<.1	.2
Nev:	Alamo	30	3.1	.1	.3
	Austin	28	30.0	<.1	1.8
	Battle Mountain	29	31.0	<.1	1.4
	Beatty	31	23.0	<.1	1.3
	Blue Eagle Ranch (Currant)	24	11.0	.1	.5
	Blue Jay	30	13.0	<.1	1.0
	Caliente	30	6.9	<.1	.5
	Currant Ranch	30	6.7	<.1	.5
	Currie	28	14.0	<.1	1.1
	Diablo	30	14.0	<.1	1.0
	Duckwater	23	15.0	<.1	.8
	Elko	30	20.0	<.1	1.1
	Ely	30	18.0	<.1	.9
	Eureka	29	22.0	<.1	1.6
	Fallini's Twin Springs Ranch	30	11.0	<.1	.8
	Fallon	30	51.0	<.1	2.7
	Frenchman Station	29	37.0	<.1	2.5
	Geyser Maintenance Station	30	14.0	.1	.8
	Goldfield	30	34.0	<.1	1.9
	Groom Lake	28	13.0	<.1	1.0
	Hiko	30	1.5	<.1	.2
	Indian Springs	31	4.5	<.1	.5

Table 2. Summary of gross beta radioactivity concentrations in air, November 1971 —continued

Location		Number of samples	Concentration[a] (pCi/m³)		
			Maximum	Minimum	Average
Nev:	Las Vegas	20	1.4	.1	.3
	Lathrop Wells	29	9.9	<.1	.6
	Lida	30	32.0	<.1	1.8
	Lovelock	30	14.0	<.1	1.1
	Lund	30	18.0	<.1	1.2
	Mesquite	30	2.7	<.1	.3
	Nyala	30	12.0	<.1	.7
	Pahrump	19	3.1	.1	.5
	Pioche	28	10.0	<.1	.7
	Reno	30	46.0	<.1	2.2
	Round Mountain	29	27.0	.1	1.6
	Scotty's Junction	29	18.0	<.1	1.5
	Stone Cabin Ranch	28	15.0	.1	1.2
	Sunnyside	13	15.0	<.1	2.4
	Tonopah	30	34.0	<.1	2.2
	Tonopah Test Range	24	15.0	<.1	1.7
	Warm Springs Ranch	30	1.6	<.1	.2
	Wells	30	21.0	<.1	.9
	Winnemucca	30	28.0	<.1	1.1
N. Mex:	Albuquerque	21	.2	<.1	.1
	Carlsbad	27	3.2	<.1	.4
Okla:	Muskogee	28	1.5	<.1	.2
Oreg:	Burns	30	2.1	<.1	.2
	Medford	24	2.3	<.1	.2
S. Dak:	Aberdeen	28	.7	<.1	.2
	Rapid City	30	.9	<.1	.1
Tex:	Abilene	28	9.2	.1	.6
	Amarillo	30	2.9	<.1	.3
	Austin	15	6.7	<.1	1.0
	Fort Worth	26	8.0	<.1	.6
Utah	Bryce Canyon	19	4.2	.1	.5
	Cedar City	26	8.0	<.1	.6
	Delta	29	8.7	<.1	.6
	Dugway	30	6.1	<.1	.5
	Enterprise	30	9.0	<.1	.6
	Garrison	30	8.8	<.1	.7
	Logan	30	2.2	<.1	.3
	Milford	30	8.9	<.1	.6
	Monticello	9	.5	.1	.1
	Parowan	26	.2	<.1	.1
	Provo	30	6.7	<.1	.5
	Roosevelt	30	7.6	<.1	.7
	Salt Lake City	30	5.3	<.1	.4
	St. George	30	3.2	<.1	.3
	Wendover	30	3.5	<.1	.3
Wash:	Seattle	22	.7	<.1	.1
	Spokane	17	.6	<.1	.1
Wyo:	Rock Springs	30	4.4	<.1	.3
	Worland	30	2.2	<.1	.2

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m³ is reported as <0.1 pCi/m³.

In support of the Cannikin Event, an underground nuclear detonation conducted November 6, 1971 on Amchitka Island, 15 additional air sampling stations were operated in Alaska during the latter part of October and the first half of November to supplement the regular network stations. Each air sampler used a glass-fiber filter and a charcoal cartridge. The analytical results for these stations will be published separately at a later date.[2]

Complete summaries of the daily station results are distributed to EPA regional offices and State health department offices. Copies of the daily gross beta results and gamma spectrometry results may be obtained from the WERL upon written request.

[2] "Final Report, Off-Site Radiological Surveillance and Public Safety for the Cannikin Event, November 6, 1971." Western Environmental Research Laboratory, Environmental Protection Agency, Las Vegas, Nev. (To be published.)

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Offsite Surveillance Around the Nevada Test Site July-December 1966 [1]

Western Environmental Research Laboratory, EPA and Nevada Operations Office, AEC

During July through December 1966, 10 announced underground nuclear tests were conducted by the U.S. Atomic Energy Commission (AEC) at their Nevada Test Site as a part of Operation Latchkey. In addition, Project Sterling was conducted underground in Mississippi as part of the Vela Uniform program. The Public Health Service (PHS) conducted a program of radiological environmental surveillance of the offsite area for the Safety Evaluation Division of the AEC's Nevada Operations Office under a Memorandum of Understanding between the PHS and AEC.

The Western Environmental Research Laboratory, EPA (WERL), formerly the Southwestern Radiological Health Laboratory, PHS, conducted this program of radiological monitoring and environmental sampling in the offsite areas surrounding the restricted area enclosed within the Nevada Test Site, Nuclear Rocket Development Station (NRDS), and the Nellis Air Force Range. The overall complex of the Nevada Test Site (NTS) and the Nellis Air Force Range includes the NRDS and the Tonopah Test Range (TTR) and for simplicity will be called the test range complex throughout this report. Although routine sampling and monitoring was done within a 300-mile radius around the test range complex, surveillance was extended as necessary to provide adequate coverage.

This report describes the methods and equipment used and summarizes the data collected during the 6-month period.

Operational procedures

Ground monitoring Prior to each event, mobile monitoring teams were deployed in the offsite area to locations most likely to be affected by a release of radioactive material. If a release did occur, the teams conducted a ground monitoring program directed from the AEC Control Point headquarters via two-way radio communications. Ground monitoring continued until activity levels essentially returned to background.

Each monitor was equipped with an Eberline E-500B, a Precision Model 111 Standard "Scintillator," and a Victoreen Radector Model No. AGB-50B-SR. The Eberline E-500B has a range of 0 to 200 mR/h beta-gamma detection in four scales with an external halogen-filled G-M tube and a 0 to 2,000 mR/h range gamma detection from an internal Anton 302 G-M tube. The Precision Model 111 Standard "Scintillator" was used primarily as an indicator of the presence of low levels of radioactivity since it provides a range of 0 to 5 mR/h in six scales. The Radector has a range of 0.05 to 50,000 mR/h over two logarithmic scales. This instrument has an inert gas ionization chamber as the detector. These instruments are accurate to ±20 percent as calibrated with cesium-137.

Exposure rate recorders To supplement the ground monitoring program, Eberline RM-11

[1] This article is a summary of report number SWRHL-38r, "Off-site Surveillance Activities of the Southwestern Radiological Health Laboratory from June through December 1966."

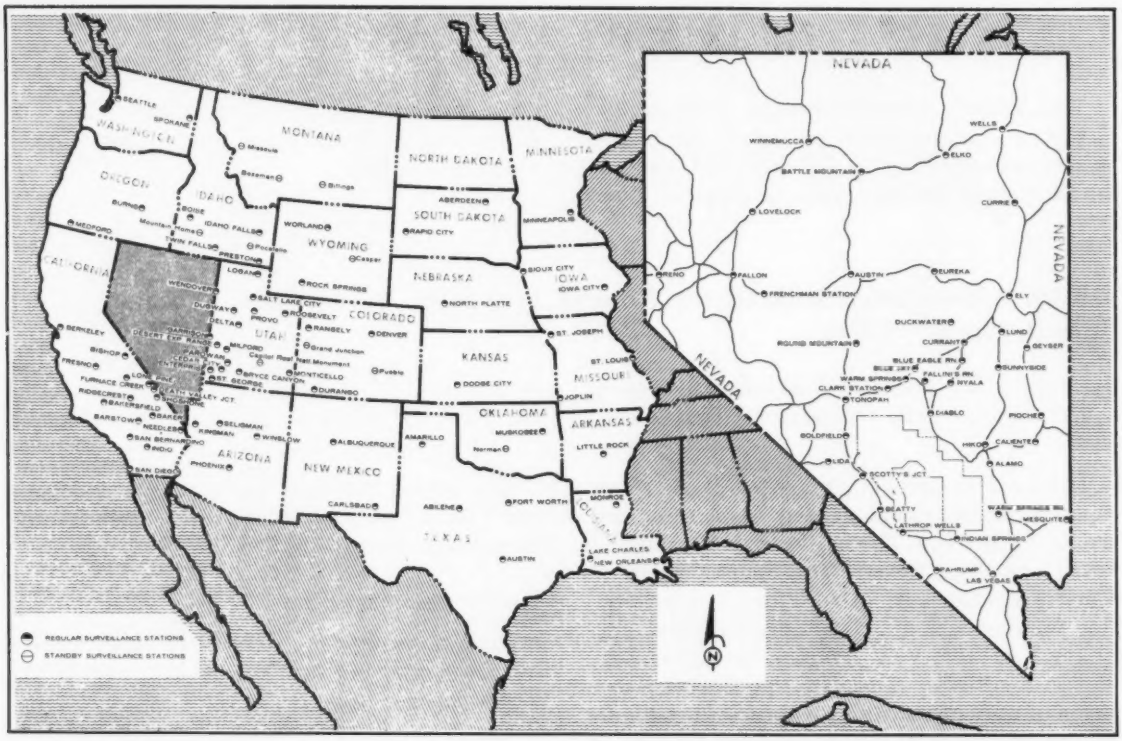

Figure 1. WERL Air Surveillance Network stations

exposure rate recorders were utilized to document cloud passage at fixed locations, thereby allowing mobile monitoring teams to continue following the release as it moved through the offsite area. These recorders have a Geiger tube detector and operate on 110 Vac. They have a 0.01 to 100 mR/h range and are calibrated to ±20 percent with a cesium-137 source. Gamma exposure rate is recorded on a 30-hour strip chart.

Aerial cloud tracking An Air Force U3-A aircraft with pilot and two monitors equipped with portable instruments identical to those of the ground monitors was used to track the effluent to assist in positioning ground monitors. Public Health Service cloud sampling aircraft were also used as aids in cloud tracking.

Air sampling During this 6-month period the WERL Air Surveillance Network consisted of 108 stations operating in every State west of the Mississippi except Montana and North Dakota (figure 1). The air sampler used in the Air Surveillance Network is a Gelman "Tempest." The "Tempest" Air Sampler consists of a Gast Model 1550 vacuum pump driven by a ½ horsepower electric motor. The pump runs at 1,440 rpm with an approximate flow rate of 10 cubic feet per minute. The sampler uses a 4-inch diameter Whatman 541 filter paper. An MSA charcoal cartridge can be added as necessary. The total volume of air sampled is calculated from an average vacuum reading and the total sampling time.

Milk and water sampling The previously established milk sampling program from both commercial dairies and private producers con-

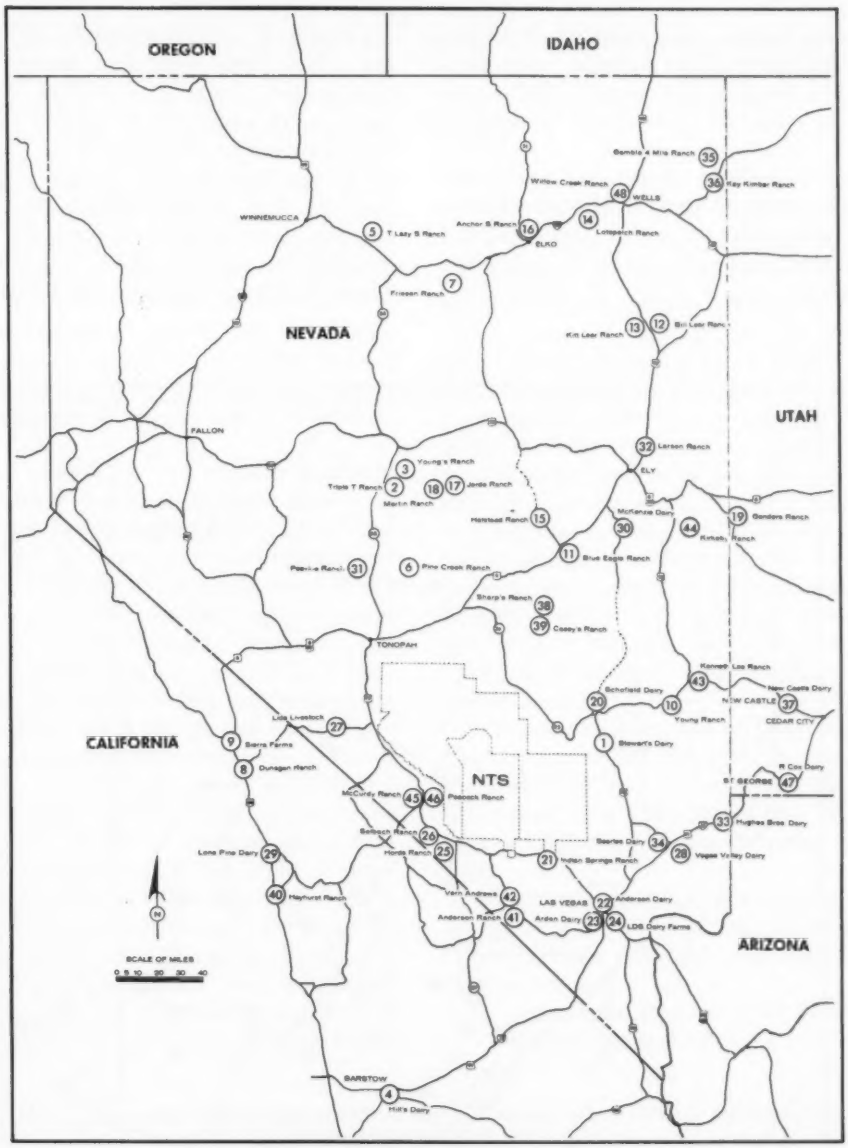

Figure 2. Routine milk sampling stations around the Nevada Test Site

tinued throughout the 6-month period. About 30 sources were routinely sampled during this period (figure 2), many on a monthly basis. A total of 100 samples was collected from these locations. In the event of cloud passage over a specific area, intensified sampling within the area was conducted to document changes in activity.

Water samples were collected on a routine basis. Water sampling was increased when a release occurred; however, because there was only one slight release during this period, only

one nonroutine sample was collected. Both potable and nonpotable water supplies were sampled routinely. During this period, 330 water samples were collected from about 70 sources (figure 3).

Vegetation sampling Normally, vegetation samples were collected only in the event of a release of radioactive material and analyzed for gross gamma radioactivity to delineate the fallout pattern.

Dosimetry Approximately 150 residents in the offsite area wore film badges throughout this period. These film badges were changed each month and were processed by the Radiological Sciences Department of Reynolds Electrical and Engineering Company, Inc. In addition, 65 film badge stations, each with five badges, were located around the test range complex to provide more complete coverage. These badges were also exchanged monthly.

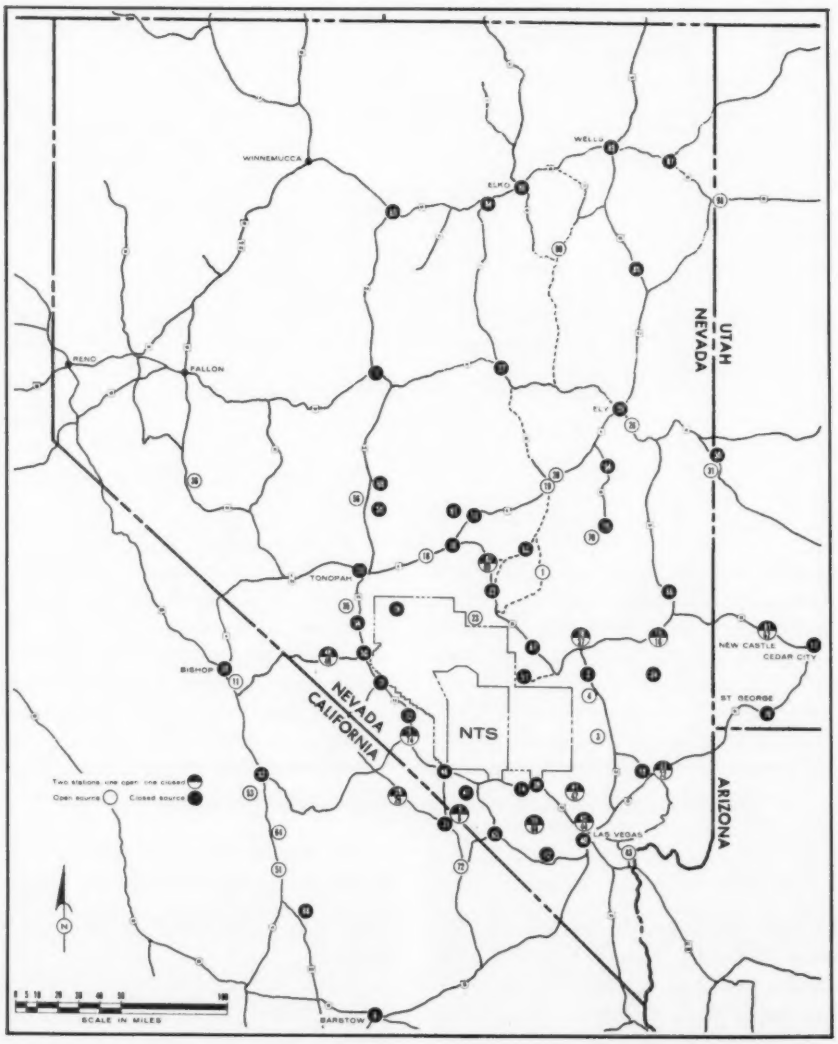

Figure 3. Water sampling stations around the Nevada Test Site

The badge used is made of DuPont type 555 film. The gamma exposure, as determined from this film, is accurate to ±50 percent in the 30 to 100 mR range and ±10 percent in the 100 to 2,000 mR range.

Approximately 20 of the 65 stations were each equipped with three CaF_2, thermoluminescent dosimeters (TLD) which were exchanged monthly with the film badges. The TLD's have a low energy photon response cutoff at 50 keV and are independent of energy in the range from 50 keV to several MeV. According to past TLD data, a reading at 10 mR above the previous month's background constitutes a detectable exposure.

Community relations Frequent contacts with the offsite population, schools and civic groups provided the opportunity to explain the role of the PHS in support of the programs of the AEC. As a result of favorable community relations, a number of offsite residents took part in the environmental sampling program; all routine air sampling stations except Las Vegas were operated by local citizens, and many people volunteered to wear film badge dosimeters.

Medical and veterinarian services A Public Health Service medical officer was available in the event any cases of a medical nature arose as a result of the test series. No such cases were brought to the attention of the PHS. Veterinarian services were provided by PHS veterinarians. Liaison was maintained with livestock producers in the area and the program of wildlife and cattle investigation was continued. Semiannual slaughter of cattle from the NTS herd and the Knoll Creek and Delmar Valley herds were accomplished in cooperation with the University of Nevada. Specimens from these animals were analyzed for radionuclide content.

Analytical procedures

All air sample prefilters and charcoal cartridges were returned to WERL in Las Vegas for radiological analyses. Prefilters were counted for gross beta activity in a Beckman "Wide Beta" low background (6 ± 1 cpm beta) proportional system which has an efficiency of approximately 45 percent for 0.54 MeV betas. After an initial count, if no significant activity was detected, the prefilters were counted at 5 and 12 days after collection. If significant fission product activity was indicated by the first count, prefilters were recounted a minimum of three times in the first 48 hours following collection. Results are then extrapolated to the end of the collection period by use of a decay constant empirically determined for each individual sample.

Selected prefilters and all charcoal cartridges were analyzed for gamma isotopes by placing them directly on a 4- by 4-inch NaI(Tl) crystal coupled to a TMC Model 404C gamma pulse height analyzer viewing energies from 0 to 2 MeV.

Detection capability of the system as shown in table 1 is an empirical estimate obtained from previous data collected under the following conditions:

1. count time in days after fissioning as indicated by footnotes,

Table 1. Threshhold detectability at time of count of several radionuclides in various samples (90 percent confidence level)

Sample number	Sample type	Iodine-131	Tellurium-iodine-132	Iodine-133	Iodine-135	Barium-lanthanum-140	Length of count
1[a]	Whatman No. 541 (pCi)	500	1,000	500	1,000	500	10 minutes
2[b]	MSA charcoal (pCi)	200	-----	200	-----	200	10 minutes
3[a]		200	400	200	400	200	10 minutes
4[b]	3.5 liter water[d] (pCi/liter)	100	-----	100	-----	100	10 minutes
5[a]		20	40–50	20–30	40–50	20	40 minutes
6[a]	3.5 liter milk[d] (pCi/liter)	20	-----	20–30	-----	20	40 minutes

[a] Counted at less than 3 days after formation.
[b] Counted at 3 days or more after formation.
[c] Assuming insignificant amounts of other nuclides, and all given isotopes at about detection limits to approximately 10 times the lower limit.
[d] Counted in 3.5 liter, inverted well (Marinelli), aluminum beakers.
[e] With cesium-137 ≤100 pCi/liter.

2. prefilters collect unfractionated fission products resulting in a complex spectrum,
3. MSA charcoal predominately collects gaseous fission products (primarily iodines),
4. an eight isotope matrix is employed for computation and isotopes other than those examined are present in amounts which are small relative to those eight, and
5. natural activity on air samples is approximately five times system background.

Although the minimum detectable levels for water samples involve the limitations listed in 4 above, the situation is usually simplified by having no background other than that of the system. For a sample containing all of the isotopes of iodine, the error term on threshold values at the 95 percent confidence level is approximately equal to ±50 percent.

Biological discrimination limits the number of isotopes present in a milk sample. Under normal sampling procedures, this discrimination coupled with the short physical half-life will tend to eliminate iodine-132 and iodine-135 from the sample by the time it is counted. At the 95 percent confidence level reported values for milk are ±10 pCi/liter or 10 percent at the time of count, whichever is greater, for a 40-minute count.

After any release of activity from the NTS, milk samples are collected from dairies (processing plants), producing dairy farms, and farms producing milk for their own consumption. Each sample is counted for 40 minutes. No attempt is made to recount samples giving low positive values. The lower limit of detection for gamma emitters in milk samples is 20 pCi/liter at the time of count, and all results below that value are reported as <20 pCi/liter.

All liquid samples are counted in 3.5 liter, inverted-well, aluminum beakers which are placed on top of a 4- by 4-inch NaI(TI) crystal coupled to a 400-channel gamma pulse height analyzer. Overall detection efficiency for the 0.364 MeV photopeak of iodine-131 is 6.4 percent. A matrix technique is employed to compute the interference due to the presence of other isotopes. The input to this matrix is variable, allowing for the simultaneous determination of any eight nuclides for which detection efficiencies and interference factors have been obtained. Actual computation is performed by an IBM 1620 computer.

Water samples are analyzed for gross beta activity by slowly evaporating an aliquot to dryness in a 2-inch diameter stainless steel planchet and counting the beta activity in a low background counter.

Results

Only one of the 10 announced detonations at the Nevada Test Site resulted in a release of radioactive effluent which was detected offsite. This was the Derringer Event of September 12, 1966.

The only positive indication of Derringer effluent offsite was by ground monitoring. Two readings slightly above background were detected in unpopulated areas. Both radiation intensities were measured on a Model 111 "Scintillator" and were less than twice background. The readings were measured at 1115 Pdt at Hancock Summit on Highway 25 and at 1120 Pdt, 10 miles southeast of Coyote Summit on Highway 25. None of the Eberline RM-11 continuous exposure rate recorders located in areas off the Nevada Test Site showed a reading above background.

Thirty air samples were collected for this event. None of these samples showed an increase in gross beta radioactivity and no fresh fission products were detectable on the Whatman 541 filter or the MSA charcoal cartridge. Other samples collected included five milk samples, one water sample, and nine vegetation samples. Short-lived fresh fission products were not detectable in any of these samples.

All milk samples collected during this period are listed in tables 2 and 3. The Project Sterling underground test conducted in Mississippi on December 3, 1966, did not release radioactivity to the atmosphere.

One additional event of interest during this period was the Greeley Event, an underground nuclear detonation conducted at 0730 hours Pst on December 20, 1966, in the Pahute Mesa area of NTS. Although a release of radioactive effluent was not expected following this detonation, the PHS provided additional personnel

Table 2. Potassium, strontium-90, and cesium-137 concentrations in milk, July–December 1966

Station	Date collected	Potassium (g/liter)	Concentration (pCi/liter)	
			Strontium-90	Cesium-137
California:				
Barstow, Hills Dairy	7/14	1.4	2	30
	8/23	1.2	4	<20
	9/15	1.2	2	<20
	10/20	1.4	.2	<20
	11/23	1.2	.9	<20
	12/14	1.0	<.1	35
Big Pine, Simmons Dairy	7/15	1.3	4	25
Bishop, Sierra Farms	7/15	1.3	6	<20
	8/25	1.2	5	20
	9/15	1.3	8	<20
	10/19	1.3	3.9	<20
	11/22	1.3	7.2	<20
	12/14	1.4	7.0	<20
Lone Pine, Lone Pine Dairy	7/14	1.2	3	45
	8/24	1.2	5	40
	9/15	1.2	3	<20
	10/20	1.2	1.4	<20
	11/22	1.4	4.0	<20
	12/14	1.3	2.8	<20
Olancha, Hayhurst Ranch	7/14	1.3	1	<20
	8/24	1.4	3	<20
	9/15	1.3	4	<20
	10/20	1.3	1.5	<20
	11/23	1.2	2.1	<20
	12/14	1.2	3.8	<20
Nevada:				
Alamo	7/14	1.2	1	25
Alamo, M. K. Stewart Dairy	7/15	1.3	2	20
	8/18	1.2	3	<20
	9/13	1.6	3	<20
	9/15	1.5	2	<20
	10/13	NA	4.1	<20
	11/16	1.2	4.3	<20
	12/22	1.5	2.6	<20
Alamo, L. L. Dairy	7/1	1.3	12	<20
	7/7	1.6	2	20
	7/14	1.2	1	25
	7/22	1.4	4	<20
	7/27	1.3	3	<20
	8/3	1.2	2	<20
Alamo, Wright Dairy	7/20	1.5	1	<20
Austin, Young Ranch	8/4	1.3	5	25
	8/31	1.6	7	<20
	9/28	1.6	7	<20
	11/3	1.5	7.6	<20
	12/1	1.4	12.2	20
Austin, Givens Ranch	7/21	1.7	9	25
	8/3	1.3	12	35
Baker, E. J. Cummings	7/5	1.5	3	<20
Baker, Baker Ranch	7/1	1.5	5	<20
Caliente, Young Ranch	7/19	1.4	2	<20
	8/18	1.3	1	<20
	9/14	NA	2	<20
	10/10	1.3	1.8	<20
	11/16	1.1	1.1	<20
	12/21	1.3	2.3	<20
Currant, Blue Eagle Ranch	8/24	1.6	4	35
	11/21	1.4	11.9	35
	12/19	1.5	10.6	55
Duckwater, Halstead Ranch	7/19	1.2	7	<20
	8/23	1.7	4	<20
	9/20	1.4	5	50
	10/18	1.3	1.8	<20
	11/18	1.1	4.8	<20
	12/19	1.4	5	<20
Duckwater, Blue Eagle Ranch	10/19	1.4	4.2	<20
Eureka, Willows Ranch	7/21	1.4	4	<20
	8/4	1.3	<.1	<20
	8/30	1.4	4	<20
	10/20	1.3	<.1	<20
Hiko, Davis Ranch	7/5	1.5	3	30
	7/12	1.3	3	30
	7/18	1.4	4	25
	7/26	1.4	4	25
	8/3	1.1	2	<20
Hiko, Schofield Dairy	7/14	1.4	2	<20
	8/18	1.3	2	<20
	9/13	1.4	3	<20
	9/15	1.6	3	<20
	10/13	NA	3.0	<20
	11/16	1.3	2.1	<20
	12/22	1.4	3.5	<20
Las Vegas, Anderson Dairy	7/6	NA	3	<20
	11/2	1.3	4.5	<20
Las Vegas, Arden Dairy	7/6	1.4	4	<20
	11/2	1.1	5	<20

See footnotes at end of table.

Table 2. Potassium, strontium-90, and cesium-137 concentrations in milk, July–December 1966 —continued

Station	Date collected	Potassium (g/liter)	Concentration (pCi/liter)	
			Strontium-90	Cesium-137
Nevada—continued				
Lathrop Wells, Damsby Ranch	8/30	1.3	1	<20
	12/27	1.1	.3	<20
Logandale, Vegas Valley Dairy or Farms	7/13	1.4	1	<20
	8/17	1.4	6	20
	9/9	1.4	4	<20
	10/25	1.3	4.6	<20
	11/28	1.2	2.6	<20
	12/29	1.3	1.7	<20
Lund	12/22	1.3	2.8	<20
Lund, McKenzie Dairy	7/8	1.5	3	25
	7/14	1.5	5	20
	7/22	1.4	3	<20
	7/29	NA	2	<20
	8/8	1.3	3	<20
	8/18	1.2	4	20
	8/30	1.4	4	<20
	9/5	1.4	3	25
	9/12	1.4	4	<20
	9/17	1.3	3	<20
	9/30	1.4	3	<20
	10/6	1.5	2	<20
	10/19	1.4	3.6	<20
	10/26	1.2	4.0	<20
	11/7	1.3	3.8	<20
	11/16	1.4	2.8	<20
	11/29	1.3	4.7	<20
	12/12	1.3	3.1	<20
	12/30	1.3	1.8	<20
Manhatten, Peavine Ranch	8/3	1.4	2	<20
	8/31	1.3	3	<20
	9/27	1.2	4	<20
	11/3	1.2	2.9	<20
Mesquite, Hughes Bros. Dairy	7/13	1.4	5	<20
	8/17	1.3	3	<20
	9/7	1.5	2	<20
	10/26	1.2	2.0	<20
	11/30	1.3	4.7	<20
	12/18	1.5	1.6	<20
Moapa, Searles Dairy	7/20	1.0	3	<20
	8/19	1.2	3	20
	10/28	1.2	3.1	20
Nyala, Sharp Ranch	7/14	1.2	11	65
	8/10	1.2	8	50
	9/15	1.5	8	<20
	10/5	1.6	11	50
	12/7	1.3	7.2	45
Pahrump, Ishmael Ranch	12/30	1.3	2.5	<20
Pioche, Horlacher Ranch	7/14	1.2	4	20
	8/17	1.4	5	30
	9/14	1.3	6	20
	10/12	1.0	4.4	<20
	11/16	1.1	8.3	<20
	12/23	1.4	4.8	25
Shoshone, Kirkeby Ranch	7/1	1.7	9	50
	7/23	1.6	10	25
	9/22	1.5	4	<20
	10/20	1.3	1.5	<20
	11/17	1.1	1.5	<20
Springdale, Peacock Ranch	11/16	1.3	1.5	<20
Tonopah, Sharps Ranch	9/8	1.5	15	<20
Winnemucca	11/8	1.2	4.7	<20
	11/10	1.1	2.9	<20
Winnemucca, P. Marcuerquiago	11/9	1.3	5.4	25
Winnemucca, 3V Dairy	11/10	1.2	3.6	<20
Utah:				
Garrison, Gonders Ranch	9/20	1.5	7	<20
	10/19	1.5	1.9	<20
	11/17	1.4	5.5	<20
Mt. Pleasant, Brooklawn Creamery	7/1	1.6	9	20
	7/2	1.4	12	<20
	7/3	1.4	9	<20
	7/4	1.3	10	<20
	7/5	1.3	11	20
New Castle, New Castle Dairy	7/14	1.4	4	<20
	8/17	1.2	5	<20
	9/8	1.4	3	<20
	10/26	1.3	4.6	<20
	12/1	1.2	4.1	<20
	12/17	1.2	2.3	<20
Ogden, Maple Leaf Dairy	7/1	1.1	10	20
	7/2	1.4	12	<20
	7/5	1.6	9	<20
	7/6	1.5	10	20

Table 2. Potassium, strontium-90 and cesium-137 concentrations in milk, July-December 1966 continued

Station	Date collected	Potassium (g/liter)	Concentration (pCi/liter)	
			Strontium-90	Cesium-137
St. George, Cox Dairy	7/15	1.4	4	<20
	7/29	1.4	5	<20
	8/6	1.4	3	<20
	8/12	1.3	5	<20
	8/19	1.3	5	<20
	8/26	1.3	3	<20
	9/2	1.3	3	<20
	9/12	1.2	8	<20
	9/16	1.3	6	25
	9/23	1.2	4	<20
	9/30	1.3	6	<20
	10/7	1.3	6	<20
	10/21	1.3	3.2	<20
	10/28	1.3	4.0	<20
	11/25	1.4	3.9	<20
	12/16	1.4	4.0	<20
	12/23	1.4	3.2	<20
St. George	7/1	1.3	3	<20
	7/22	1.1	5	<20
	10/14	1.4	3.5	<20
	11/3	1.3	3.9	<20
	11/11	1.4	5.4	<20
	11/18	1.3	3.7	<20
	12/2	1.3	2.5	<20
	12/9	1.4	3.5	<20
	12/30	1.4	4.3	<20
Smithfield	7/5	1.6	11	<20
	7/6	1.6	11	<20
	7/7	1.6	11	<20
Smithfield, Cache Valley Dairy	7/1	1.5	13	30
	7/2	1.4	10	25

NA, no analysis.

for ground motion studies because the Greeley device was of relatively large yield and ground motion was anticipated as far as 75 miles from ground zero.

Seventy-five personnel from WERL participated in the surveillance activities for this event. Community information centers were established in Tonopah, Goldfield, Beatty, and Alamo in order to inform the members of these communities of the exact time of the detonation and what degree of motion could be expected. PHS personnel were also available to answer questions in Ely, Caliente, Pioche, and Las Vegas.

All active mines in the vicinity of NTS were located and mining personnel were advised not to be underground at the time of the detonation.

No release of radioactive effluent occurred as a result of this detonation, either initially or in the followup operations. No damage to offsite structures from ground motion was reported to any of the community information centers.

Conclusions

Results obtained through environmental radiation surveillance during this period indicate that no individual in the offsite area received an exposure, resulting from Nevada Test Site operations, which exceeded the guides established by the AEC and/or recommended by the FRC and the NCRP.

Table 3. Strontium-89, iodine-131, ruthenium-103, and barium-140 in milk samples, July–December 1966

Station	Date collected	Concentration[a] (pCi/liter)			
		Strontium-89	Iodine-131	Ruthenium-103	Barium-140
California:					
Bishop, Sierra Farms	7/15	5			
Olancha, Hayhurst Ranch	7/14	5			
	11/23		50		
	12/14	5			
Nevada:					
Alamo	7/14	5			
Alamo, M. K. Stewart Dairy	7/15	5			
Alamo, L. Lee Dairy	7/1	5			
	7/14	5			
Austin, Givens Ranch	7/21	5	30		
Baker, E. J. Cummings	7/5	5			
Baker, Baker Ranch	7/1	5	20		
Caliente, Young Ranch	7/19		60		
Duckwater, Halstead Ranch	7/19	5			
	12/19			30	
Duckwater, Blue Eagle Ranch	10/19	5.5			
Hiko, Davis Ranch	7/5	5			
	7/12	5			30
	7/18	5	70		
Las Vegas, Arden Dairy	7/6	5			
Lathrop Wells, Dansby Ranch	8/30	5			
Logandale, Vegas Valley Dairy	7/13	5			
Lund, McKenzie Dairy	7/14	5			
	9/17	15			
Nyala, Sharp Ranch	12/7		10		
Pioche, Horlacher Ranch	7/14	10			
	12/23	6			
Shoshone, Kiekeby Ranch	7/23		60		
Springdale, Peacock Ranch	11/16	5			
Utah:					
Mt. Pleasant, Brooklawn Creamery	7/1	10			
	7/2	10			
	7/3	15			
	7/4	15			
	7/5	10			
New Castle, New Castle Dairy	7/14	5			
Ogden, Maple Leaf Dairy	7/1	5			
	7/5	5			
St. George, Cox Dairy	7/29	5			
St. George	7/1	5			
Smithfield	7/5	10			
	7/6	5			
	7/7	5			
Smithfield, Cache Valley Dairy	7/2	15			

[a] Only detectable concentrations of strontium-89, iodine-131, ruthenium-103, and barium-140 are listed. These radionuclides were nondetectable in all other samples.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of a nature that plant environmental surveys are required.

Releases of radioactivity materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

A summary of the environmental radioactivity data follow for Neutron Devices Department and the Paducah Plant.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Neutron Devices Department[2] July–December 1970

General Electric Company
St. Petersburg, Fla.

The Neutron Devices Department (figure 1) is an electronic component production facility. The plant maintains an environmental monitoring program to measure the levels of radioactive environmental contamination associated with plant effluents. These measurements serve as an index of the effectiveness of the plant's contamination control measures. Sewer effluent, surface water, milk and air within 6 miles of the plant are monitored for radioactivity. The radioactivity concentrations, weighted by atmospheric and stream dilution factors, are compared against the AEC standards for continuous nonoccupational exposure as presented in the AEC Manual, chapter 0524.

Sewer effluent monitoring

Waste water discharges from the plant were routinely sampled and analyzed for radioactive material at the site's boundary. A total of 214 samples was obtained and analyzed for tritium content. In those instances where detectable concentrations occurred, the radioactivity resulted from controlled releases. Radioactivity releases from the process waste system into the plant's water effluents resulted in an average tritium concentration for the period of less than 5 percent of the AEC standard for continuous nonoccupational exposure.

Surface water sampling

There were no indications of tritium in 127 routine surface water samples collected from areas surrounding the plant. These sample locations represent an area up to 6 miles in all directions from the plant site and are not related to the wastewater effluent from the plant.

Milk sampling results

Analyses of 12 raw milk samples, provided by the Pinellas County Health Department from the one local dairy farm, revealed no detectable concentrations (detectable level—90 nCi/liter) of tritium.

Air sampling results

A total of 12 air samples was obtained during times of radioactivity releases. Analyses of these samples revealed that the maximum concentration, occurring over a period of 30 minutes, represented only 3.6 percent of the AEC standard for tritium oxide in air for continuous nonoccupational exposure.

Summary

Offsite radioactivity concentrations encountered by the general population are substantially lower than the AEC standards for continuous nonoccupational exposure.

[2] Summarized from "Environmental Monitoring, July 1 through December 1970," General Electric Company, Neutron Devices Department, St. Petersburg, Fla.

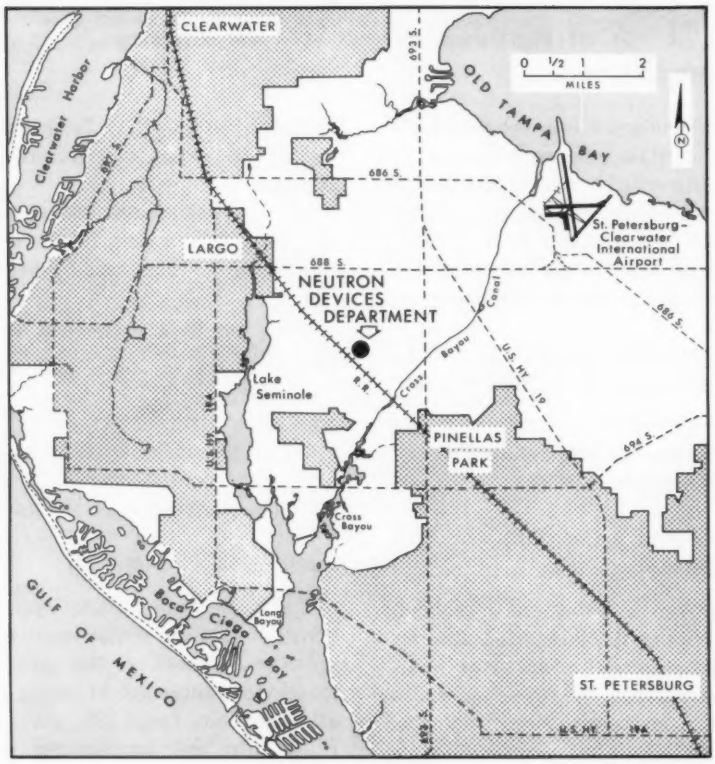

Figure 1. Location of the Neutron Devices Department

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July-December 1969	August 1970
January-June 1970	February 1971

2. Paducah Plant[3] July–December 1970

Union Carbide Corporation
Paducah, Ky.

The Paducah Plant is a government-owned gaseous diffusion plant operated by the Nuclear Division of the Union Carbide Corporation for the Atomic Energy Commission. The diffusion plant processes large quantities of relatively pure uranium compounds. Facilities on the site, in addition to the diffusion cascade, include a feed manufacturing plant, a metals plant, and a decontamination and uranium recovery unit.

The uranium enrichment areas (diffusion cascade) operate with a very low loss of material. Millions of pounds of uranium hexafluoride may be fed to, diffused in, and withdrawn from the cascade with the loss of only a few pounds per year. There is a slight loss of uranium to the atmosphere when diluent

[3] Summarized from "Environmental Concentrations of Radioactive Materials near the Paducah Plant—Report for the year 1970 and the second half of 1970."

gasses are purged from equipment units or from the cascade. Some uranium on cascade equipment replaced for maintenance or modification is removed in the decontamination facility.

The handling of powdered uranium salts in the feed manufacturing plant requires the extensive use of vacuum and local exhaust systems. Various filter units are used to remove uranium from exhaust air. The uranium hexafluoride product is separated from entrained solids, excess fluorine, and diluent gases by a series of cyclones, filters, cold condensers, and fluid bed absorbers. Unreacted uranium and beta active uranium decay products separated from the uranium hexafluoride in the fluorination system are stored for radioactive decay and processed through uranium recovery facilities.

The effluents to be considered in the handling of uranium solids and the use of vacuum and local exhaust systems in the metals plants are similar to those of the feed plant. In addition, the plant generates about 1,200 pounds of contaminated magnesium fluoride slag for every ton of uranium metal produced. This slag is collected and eventually buried onsite.

The environmental monitoring program provides for continuously sampling the air at four stations around the plant perimeter fence, and at five stations located approximately 1 mile outside this fence (figure 2). Big Bayou and Little Bayou waters are sampled continuously, and grab samples are collected at five locations in the Ohio River and at the mouth of the combined Bayou Creeks. In addition, gamma radiation readings are taken each month at each of the air sampling stations with a Geiger-Mueller type meter at a distance of 3 feet above ground level.

Basic standards

The radiation protection standards observed for the in-plant work environment of employees and for offsite exposure of the general population are those contained in Appendix 0524 of the AEC manual.

Discussion

Data summarizing the environmental concentrations of radioactive materials in air and water and the gamma radiation levels in the vicinity of the Paducah Gaseous Diffusion Plant are presented in tables 1 through 5. The source of the radioactivity detected is considered to be uranium (alpha) and the radioactive daughters of uranium (beta). The average uranium concentration in air at the perimeter fence was 1 percent of the AEC standards for people residing in the vicinity of a controlled area. The average air concentration at the 1-mile stations was 0.5 percent of the AEC standard. The concentration of gross beta radioactivity was 0.04 percent and 0.02 percent of the AEC standard at the 1-mile stations, respectively. The average analysis of nine grab samples

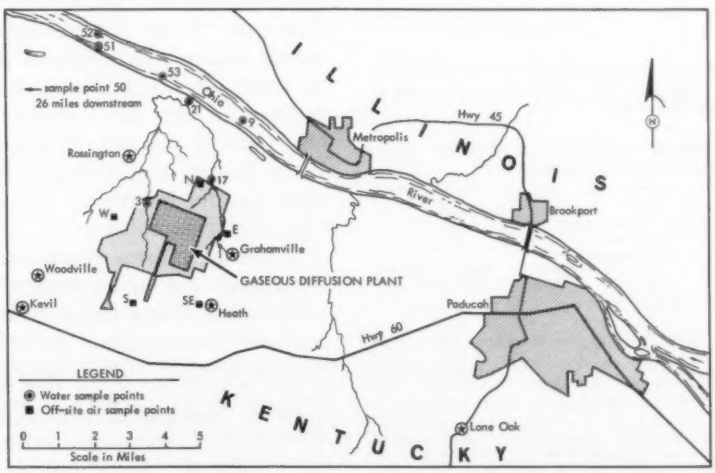

Figure 2. Sampling locations, Paducah Gaseous Diffusion Plant

Table 1. Uranium concentrations in outdoor air samples Paducah Plant, July–December 1970

Sample locations[a]	Number of samples	Uranium alpha radioactivity[b] (fCi/m³)		
		Maximum	Minimum[c]	Mean[d]
At plant perimeter fence:				
North	26	70	<20	20
East	26	410	<20	50
South	26	100	<20	10
West	26	170	<20	20
Summary	104	410	<20	20
About 1 mile outside plant perimeter fence:				
North	26	80	<20	20
East	26	100	<20	20
South	26	90	<20	10
West	26	60	<20	10
Southeast	26	70	<20	10
Summary	130	100	<20	10

[a] See figure 2.
[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57×10^4 alpha dis/s.
[c] The minimum detectable concentration of uranium in air is 20 fCi/m³.
[d] The AEC standard for natural uranium in air released to the environs beyond a controlled area is 2 pCi m³.

Table 2. Gross beta radioactivity in outdoor air samples Paducah Plant, July–December 1970

Sampling station[a]	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum[b]	Mean[c]
At plant perimeter fence:				
North	26	7.2	<0.1	0.44
East	26	1.2	<.1	.29
South	26	.63	<.1	.16
West	26	.68	<.1	.19
Summary	104	7.2	<.1	.27
About 1 mile outside plant perimeter fence:				
North	26	.44	<.1	.18
East	26	.44	<.1	.18
South	26	.63	<.1	.18
West	26	.50	<.1	.18
Southeast	26	.43	<.1	.18
Summary	130	.63	<.1	.18

[a] See figure 2.
[b] The minimum detectable concentration of gross beta radioactivity in air is 0.1 pCi/m³.
[c] The AEC standard for immediate daughter products of uranium in air is 1 nCi/m³ (standard for thorium-234).

Table 3. Concentrations of uranium in water Paducah Plant, July–December 1970

Sample locations[a] and station number	Number of samples	Uranium[b] (pCi/liter)		
		Maximum	Minimum[c]	Mean[d]
Big Bayou 3	26	18	<1	4
Little Bayou 17	26	140	3	43
Mouth of Bayou Creeks 21	5	7	<1	2
Ohio River 9	5	2	<1	<1
Composite of 50, 51, 52, and 53	5	1	<1	<1

[a] See figure 2.
[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57×10^4 alpha dis/s.
[c] The minimum detectable concentration of uranium in water is 1 pCi/liter.
[d] The AEC standard for natural uranium in water beyond a controlled area is 20 nCi/liter.

Table 4. Concentration of gross beta radioactivity in water, Paducah Plant, July–December 1970

Sample locations[a] and station number	Number of samples	Gross beta radioactivity (pCi/liter)		
		Maximum	Minimum[b]	Mean[c]
Big Bayou 3	26	600	<100	<100
Little Bayou 17	26	12,000	<100	700
Mouth of Bayou Creeks 21	5	<100	<100	<100
Ohio River 9	5	<100	<100	<100
Composite of 50, 51, 52, and 53	5	200	<100	<100

[a] See figure 2.
[b] The minimum detectable amount of gross beta radioactivity in water is 100 pCi/liter.
[c] The AEC standard for the immediate daughter products of uranium in water beyond a controlled area is 20 nCi/liter.

Table 5. External gamma radiation levels July–December 1970

Sample locations[a]	Number of readings	Average gamma radiation (μR/h)
At plant perimeter fence:		
North	5	20
East[b]	5	30
South	5	20
West	5	20
Summary	20	20
About 1 mile outside plant perimeter fence:		
North	5	20
East	5	20
South	5	20
West	5	20
Southeast	5	20
Summary	25	20

[a] See figure 2.
[b] Near uranium hexafluoride cylinder storage area.

taken at the mouth of the creeks reflects the dilution provided by overflow from the Tennessee Valley Authority ash pond; these analyses averaged 0.01 percent of the AEC standard. Uranium in the Ohio River was not significantly above the detection limit. Beta activity in these drainage streams was less than 0.5 percent of the AEC standard in Big Bayou, less than 5 percent of the AEC standard in Little Bayou, and averaged below the detection limit at the mouth of the creeks and in the Ohio River samples.

External gamma radiation in the vicinity of the Paducah Plant averaged 0.02 mR/h at all sampling stations for July-December 1970, except for the east plant perimeter station which had an average of 0.03 mR/h.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July-December 1969	September 1970
January-June 1970	March 1971

Reported Nuclear Detonations, March 1972

(Includes seismic signals presumably from foreign nuclear detonations)

Seismic signals, presumably from a Soviet underground nuclear explosion, were recorded by the United States on March 10, 1972. The signals originated from the Semipalatinsk nuclear test area and were equivalent to those of an underground nuclear explosion in the yield range of 20–200 kilotons.

The Peoples Republic of China set off a nuclear explosion in the atmosphere at approximately 1 a.m., EST, March 18, 1972, at their Lop Nor nuclear test area in northwest China. The yield was in the range of 20–200 kilotons.

The United States recorded seismic signals on March 27, 1972, presumably from a Soviet underground nuclear explosion. The signals originated a few minutes before midnight, EST, March 27, 1972, at the Semipalatinsk nuclear test area and were equivalent to those of an underground nuclear explosion in the yield range of 20–200 kilotons.

There were no reported nuclear detonations for the United States for March 1972.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

DISTRIBUTION OF CESIUM-137 AND NATURALLY OCCURRING RADIONUCLIDES IN SEDIMENTS OF LAKE MICHIGAN. *Phillip A. Plato. Radiation Data and Reports,* Vol. 13, April 1972, pp. 181–187.

Measurements of radioactivity in bottom sediments of Lake Michigan were made during 1969 and 1970. The only manmade radionuclide found was cesium-137 which originated from over two decades of atmospheric testing of nuclear weapons. A correlation was observed between accumulation of cesium-137 in sediments and water current patterns in Lake Michigan. Concentrations of naturally occurring potassium-40 and radium-226 were found to correlate with the type of sediment present.

KEYWORDS Cesium-137, Lake Michigan, potassium-40, radium-226, sediment, water.

RADIOACTIVITY LEVELS IN SELECTED OHIO STREAMS; THE GREAT MIAMI RIVER, THE LITTLE MIAMI RIVER, AND MILL CREEK; JUNE-AUGUST 1968. *Office of Water Programs, U.S. Environmental Protection Agency, Radiation Data and Reports,* Vol. 13, April 1972, pp. 189–194.

A water quality study of the Little Miami River, Great Miami River, and Mill Creek was conducted by the Office of Water Programs, U.S. Environmental Protection Agency. Analyses were performed for uranium, radium-226, lead-210, thorium and strontium-90. Uranium concentrations in the Little Miami River, Great Miami River, and Mill Creek averaged 0.4, 0.9, and 0.3 μg/liter, respectively. Radium-226 concentrations averaged 0.08, 0.11, and 0.04 pCi/liter, respectively. Strontium-90 concentrations averaged 0.7, 0.4, and 1.1 pCi/liter, respectively. The average thorium concentration was less than 3 μg/liter in all three streams. Lead-210 averaged less than 0.2 pCi/liter in the Little and Great Miami Rivers and 0.7 pCi/liter in Mill Creek.

KEYWORDS: Lead-210, Ohio, radionuclides, radium-226, rivers, strontium-90, surface water, thorium, uranium.

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